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Influence of water-level regulation on littoral macrozoobenthos of Flathead Lake Montana

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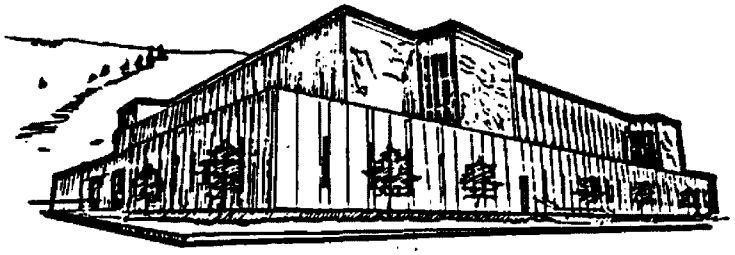

INFLUENCE OF WATER-LEVEL REGULATION ON LITTORAL MACROZOOBENTHOS OF FLATHEAD LAKE, MONTANA

by

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ABSTRACT

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Influence of Water-Level Regulation on Littoral Macrozoobenthos of Flathead Lake, Montana

Major Professor: Dr. F. Richard Hauer RH

The annual pattern of water-level changes in Flathead Lake has been altered by dam operations, resulting in an extended duration of high lake-levels followed by winter dewatering of the nearshore environment. This altered regime may affect benthic macroinvertebrates residing in the shallow (<5m) rocky littoral zone. This study compared macrobenthos communities in the permanently wetted (4.5m full-pool depth) and seasonally dewatered (1.5m full-pool depth) zones of Flathead Lake and a nearby unregulated lake, Lake McDonald. Samples were collected seasonally using an underwater air-lift device.

Regulation did not appear to have an adverse impact on total macrobenthic abundance in the littoral zone of Flathead Lake. However, conditions which were enhanced by regulation (i.e. increased erosion and autochthonous production) appeared to influence the distribution, composition, and abundance of some species. Lower mean abundances of shredders, plant-case building Trichoptera, and diving/clinging-type fauna (Coleoptera and Hemiptera) in Flathead Lake may be related to decreased riparian vegetation and allochthonous material owing to prolonged wave action on the shoreline. Conversely, grazers and collectors (Insecta) which preferred erosional-type environments were more abundant in the seasonally inundated zone of Flathead Lake owing to the presence of suitable periphyton and substratum. Offshore transport and deposition of sediments and sloughed periphyton due to regulated lake-levels appeared to create a favorable habitat for the burrowing-type collectors, Chironomidae and *Hyalella azteca*, which were highly abundant in the permanently wetted zone of Flathead Lake. The synergistic effects of increased nutrient inputs and altered lake-levels has resulted in a thick periphyton "carpet" in the permanently wetted zone of Flathead Lake. This offshore mat, containing fine sediment deposits, created a habitat unfavorable for offshore grazers (Elmidae), which were highly abundant in the permanently wetted zone of Lake McDonald. Finally, the altered fluctuation regime may interrupt life cycles of certain species via stranding of eggs (*Capnia confusa*) or prolonged inundation of pupation sites (Elmidae).

The air-lift sampler, operated by SCUBA gear, collected quantitative macrobenthic samples from large cobble substratum. Performance of the air-lift was evaluated by conducting efficiency tests and comparing the air-lift to rock basket samplers. The air-lift sampler operated with an estimated efficiency of 71% in the nearshore zone (1.5m depth) of Flathead Lake. The air-lift and basket samplers contained similar taxonomic compositions; however, baskets collected significantly ($P<.05$) greater densities of total organisms along turbulent and irregular bottoms than the air-lift sampler. Improvements for the air-lift technique are discussed.

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PREFACE

Kerr Dam, located 6km downstream of Flathead Lake, is owned and operated by Montana Power Company. This dam regulates the water-level of Flathead Lake for hydroelectric purposes. Kerr Dam recently reached its 50 year relicensing period. Thus, Montana Power Company was mandated by the Federal Energy and Regulatory Commission to document the impacts of Kerr Dam operations on the Flathead Lake/River System and to develop a mitigation program to ameliorate these effects. The Flathead Lake Biological Station was funded by Montana Power Company for various studies on the shoreline ecology of Flathead Lake, including partial funding which initiated my thesis work.

Preliminary investigations began in August 1990 and results of this pilot study were published in the 1991 *Proceedings of the Montana Academy of Science*. However, I report herein a more extensive study which was conducted during 1991. The thesis consists of two chapters. Chapter One, entitled "Influence of Water-Level Regulation on Littoral Macrozoobenthos of Flathead Lake, Montana", contains the main thesis study. This study was presented at the 1992 meeting of the *North American Benthological Society Meeting*, University of Louisville, Kentucky. Chapter Two, entitled "A Benthic Air-lift Sampler Suitable For Large Cobble Substratum", describes in detail the construction, operation, and performance of the air-lift sampling device used in the main study. Both papers will be submitted for professional publication.

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INTRODUCTION

Altered lake-level fluctuations caused by dams are known to have deleterious effects on the littoral bottom fauna (Alasaarela et al., 1989; Benson and Hudson, 1975; Dunn, 1961; Grimas, 1961, 1962, 1964, 1965a, 1965b; Hynes, 1961; Hynes and Yadav, 1985; Hunt and Jones, 1972a, 1972b; Kaster and Jacobi, 1978; Kallemeyn and Cole, 1988; May et al., 1987; McLachlan, 1974; Paterson and Fernando, 1969; Stube, 1958; Tikkanen et al., 1988). The shallow littoral zone generally supports the most diverse benthic macroinvertebrate community of a lake owing to the diversity of habitats ranging from well protected, vegetated bays to exposed rocky shorelines (Barton and Hynes, 1978a, 1978b, 1978c; Barton and Smith, 1984; Dall et al., 1984; Fryer, 1959; Krecker and Lancaster, 1933; Macan, 1980; Moon, 1934; Rawson, 1930; Ward, 1992). It is this environment of the lake which is most likely to be influenced by changes in the natural fluctuation regime of a lake.

Many littoral macrobenthos residing in naturally fluctuating lakes are adapted to changing water levels. Some aquatic forms migrate into the varial zone (ie. the nearshore region which is seasonally inundated and dewatered) during high water levels and subsequently retreat to the permanently wetted zone during low water levels (Moon, 1935, 1940; Wesenberg-Lund, 1908). Others may burrow into dewatered substratum and remain protected from

harsh conditions until the varial zone becomes rewetted (Kaster and Jacobi, 1978). Phenological adaptations are also exhibited by some insect species. Certain organisms may pupate within protected areas of the dewatered varial zone (Seagle, 1980; White, 1978). Others may emerge during declining water-levels and deposit eggs in the permanently wetted area of the littoral zone. However, many benthic macroinvertebrates which colonize the littoral zones of regulated lakes may not have survival strategies adapted to temporal changes in littoral zone dewatering. Consequently immature stages may become stranded in the varial zone and exposed to harsh conditions such as desiccation and/or freezing (Grimas, 1961, 1962; Hunt and Jones, 1972a; Hynes, 1961; Kaster and Jacobi, 1978; Kallemeyn and Cole, 1988).

Lake-level regulation may also indirectly affect the benthic fauna by physically altering rocky substratum, aquatic macrophytes, and hence the distribution of biofilms (Grimas, 1961, 1962, 1964; Hynes, 1961). Increased water-level fluctuations or retention of full- pool levels beyond the natural season may cause finer sediments to be eroded from the shoreline (Lorang et al., *in press*) and redeposited over organic material in the offshore littoral region; thereby possibly reducing food availability (Ward, 1992) or interfering with grazing on periphyton. Reduction of aquatic macrophytes and riparian vegetation due to erosion (Lorang et al., *in press*, Quennerstedt, 1958) may result in a substantial decrease in substratum diversity, oviposition sites, and benthic organic matter.

In addition, leaves and other material from riparian vegetation are utilized by many macroinvertebrates as food sources (Anderson and Sedell, 1979), substratum (Ward, 1992), and case-building materials for caddisflies (Minshall, 1984; Wiggins, 1977).

The most severe effects of regulation occur immediately after the establishment of an impoundment, resulting in a drastic reduction of benthic abundance and diversity (Grimas, 1964, 1965b; Hunt and Jones, 1972a; Hynes, 1961). After several years of regulation, some benthic macroinvertebrates may re-establish in the shallow littoral zone; however, the balance between the dominant groups and abundance of certain species may remain altered after decades of regulation (Hynes and Yadav, 1985).

Flathead Lake (Montana, USA), one of the 300 largest lakes in the world, has been regulated by a hydroelectric dam for over 50 years. Unlike most regulated lakes or reservoirs studied, the amplitude of lake-level fluctuation (3m) has not been drastically altered. However, the natural high water-level reached during summer is retained for an extended period, resulting in gradual winter dewatering of the nearshore environment. The purpose of this study was to determine the effects of lake-level regulation on the benthic macroinvertebrate community residing in the shallow (<5m depth) rocky littoral zone of Flathead Lake. Due to lack of quantitative data from Flathead Lake prior to regulation, nearby Lake McDonald (Glacier National Park, USA) was used as a reference for this study. Lake McDonald's shoreline is also characterized by large

rocky substratum, but its water-level fluctuates naturally. This study compared the macrozoobenthos community composition, abundance, and distribution between the two lakes in relation to changes in food resources and substratum.

STUDY LAKES

Flathead Lake and Lake McDonald are located in a montane region in northwestern Montana. Flathead Lake (48°23'N;114°8'W) lies west of the Continental Divide at an elevation of 882m. Lake McDonald (48°35'N;113°55'W), 100km northeast of Flathead Lake, is situated in southwestern Glacier National Park at an elevation of 960m (Figure I.1). Both lakes are large, deep, and oligotrophic (Ellis et al., 1991; Stanford et al., 1983). Surface temperatures range from freezing or near freezing during winter to 20°C and 15°C during summer in Flathead Lake and Lake McDonald respectively (Table I.1). Snow melt provides large volumes of water into Flathead Lake and Lake McDonald during the spring freshet (Stanford et al., 1983). Under natural conditions, the water-levels of both lakes fluctuate; lake-levels rise approximately 2-4m during spring runoff and decline to base levels by mid-summer (August).

In 1938, a hydroelectric dam was constructed 6km below the Flathead Lake outlet (Figure I.1). Dam operations have altered the natural fluctuation regime of the lake. Although the lake-level still rises naturally during spring snow melt, the maximum lake elevation (882m) is retained until late summer. Lake-levels decline during

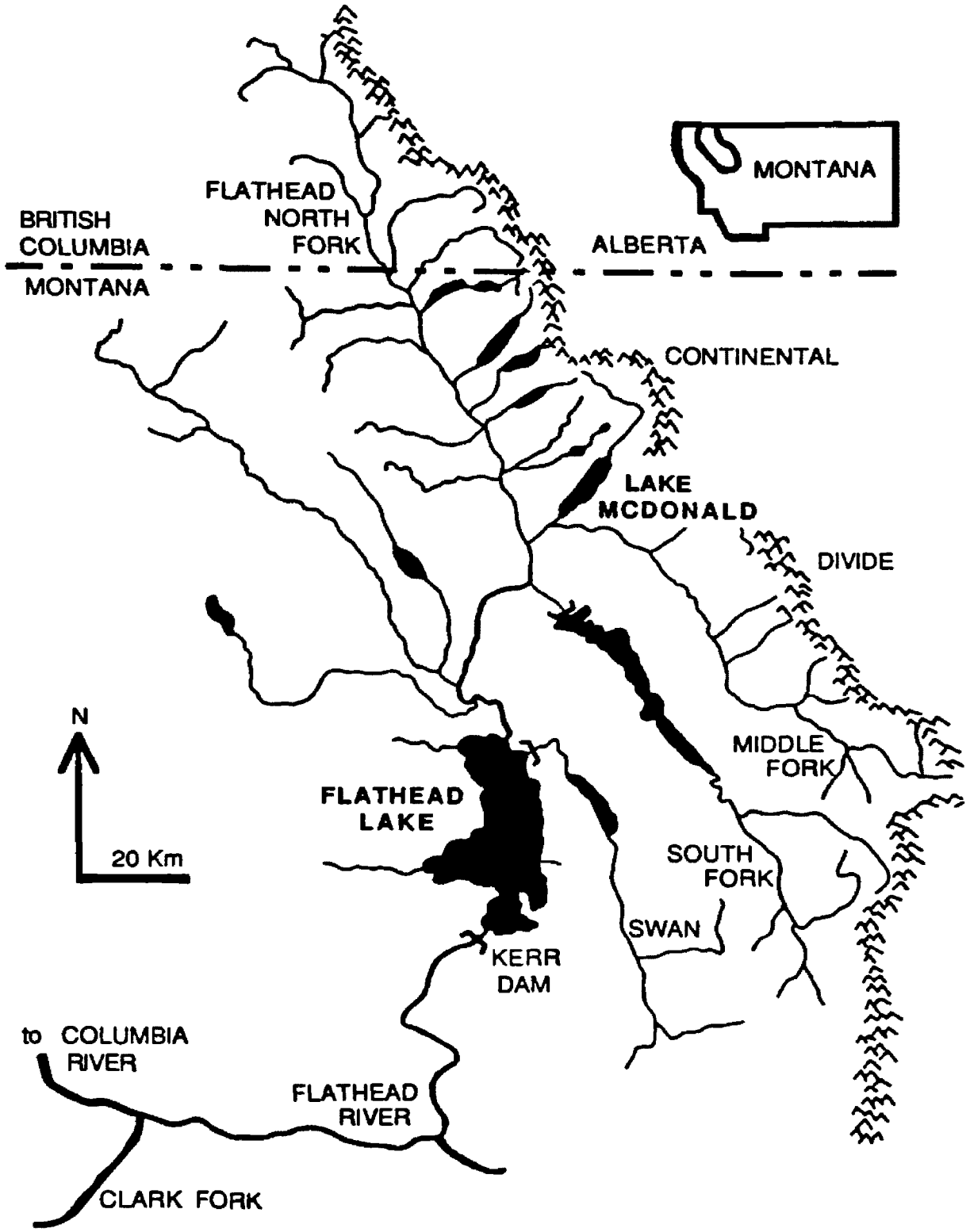

Figure I.1 Flathead River Basin.

Table 1.1. Lake characteristics and sampling regime of Flathead Lake and Lake McDonald; vz=varial zone, pwz=permanently wetted zone, x=samples collected, dw=dewatered (no samples collected)

	Flathead Lake	Lake McDonald
Lake Characteristics		
Elevation (m)	882	960
Surface Area (Km^2)	496	29
Maximum Depth (m)	115	142
Length (Km)	45	14
Width (Km)	24	3
Maximum Surface Temp. (^oC)	20	15

	Flathead Lake		Lake McDonald	
Sampling Regime	vz	pwz	vz	pwz
Spring (May)	dw	x	dw	x
Summer (August)	x	x	x	x
Autumn (Oct/Nov)	x	x	dw	x

winter as water is used for hydropower. Thus, the varial zone of Flathead Lake is inundated 4-6 months longer than prior to regulation and gradually becomes dewatered during winter instead of summer (Figure I.2). Lake McDonald is not regulated, and its annual fluctuation pattern is similar to pre-regulated Flathead Lake.

METHODS

Sampling design

Two study sites were established in each lake. Flathead Lake sites were located approximately 3km apart along the east shore, near the University of Montana's Biological Station. Lake McDonald sites were located approximately 1km apart along the southwest shore, 2km north of Apgar Village. The study sites were characterized by large cobbles underlain by small stones, gravel, and/or sand. Winds caused frequent wave action along the exposed rocky shorelines of the two lakes, thus creating nearshore erosional-type habitats with little or no macrophytes. Cottonwood, aspen, birch, and conifers composed the major riparian vegetation along the study sites of both lakes.

Two 30m-transects, paralleling the shore, were established at each of the two sites in each lake; one transect was located in the varial zone (1.5m depth at full pool) and the other transect was established within the permanently wetted zone (4.5m depth at full pool). Transect locations remained fixed throughout the study regardless of changing water levels. Five to six random samples

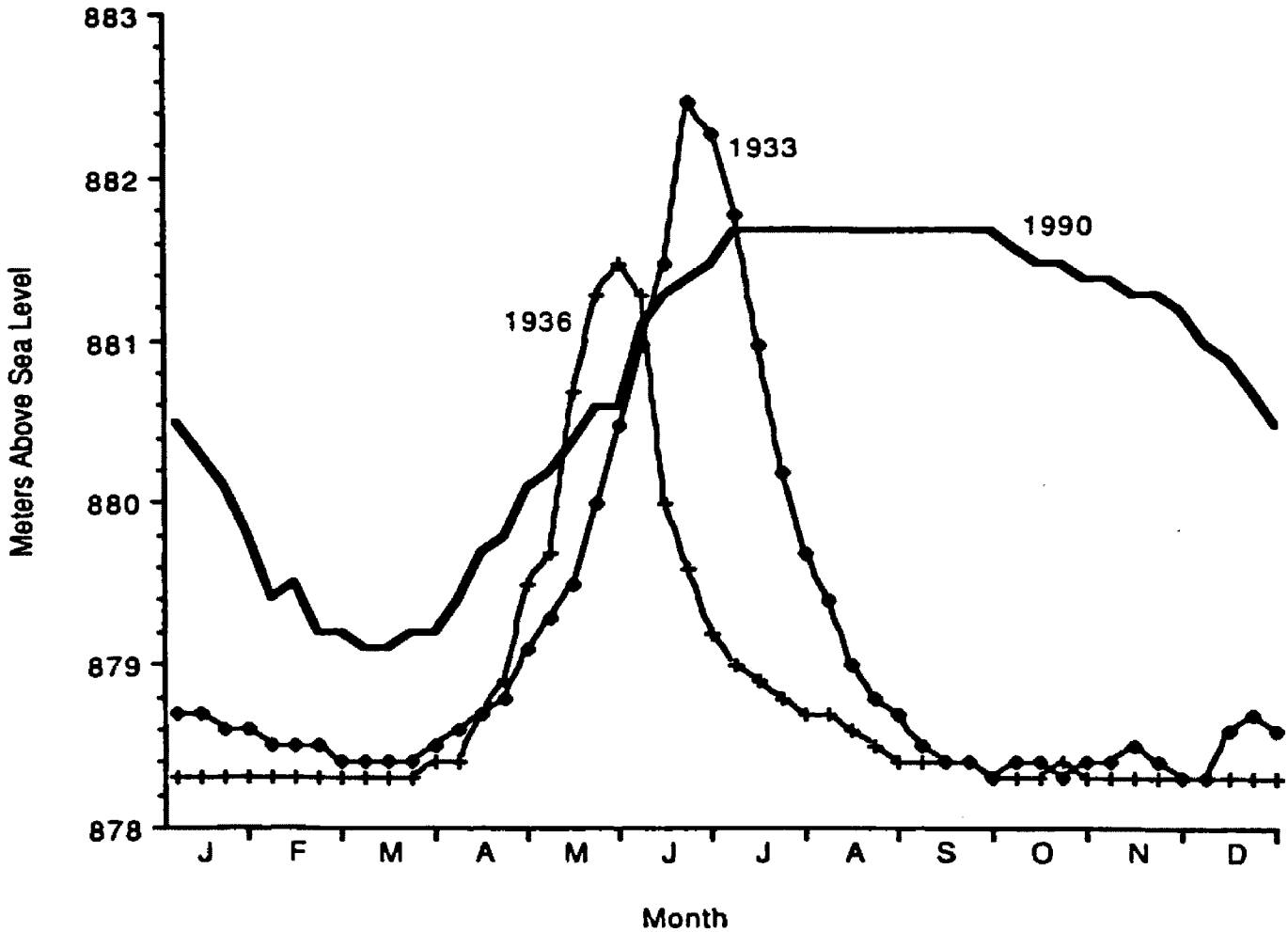

Figure I.2 Annual water-level fluctuations of Flathead Lake before regulation (1933 & 1936) and after regulation (1990).

were collected along each transect during three sampling periods (spring, summer, and autumn 1991). The varial zone transects were sampled only when inundated (Table I.1). Individual sample areas (0.185m^2) were chosen using a stratified random design by dividing each 30m-transect into three 10m-sections and randomly collecting two samples within each 10m-section.

Macrobenthos sampling and sorting

An underwater air-lift sampler was designed to collect organisms directly from the undisturbed rocky substratum (Figure I.3). This sampler was operated by a SCUBA diver. Details of its construction and operation are found in Chapter Two. Organisms and benthic organic matter were vacuumed into a 150μm mesh collection bag. For each sample, all cobbles and gravels were vacuumed to a depth of approximately 1cm for 5 minutes within the confines of a metal frame (0.185m^2 area).

Entire air-lift samples were transferred from the mesh bag to 500ml jars and preserved in 70% ethanol. Samples were separated into organic and inorganic portions by decanting the organic material into a separate enamel pan. Rocks and gravels were sorted through a series of sieves (2mm, 500μm, and 150μm) and each portion was hand picked for invertebrates. Organic material (>150μm) was hand picked and then randomly subsampled (1/2-1/32 fractions, depending upon the amount of material) under a dissecting scope (6x and 12x) for smaller organisms, primarily chironomids and early

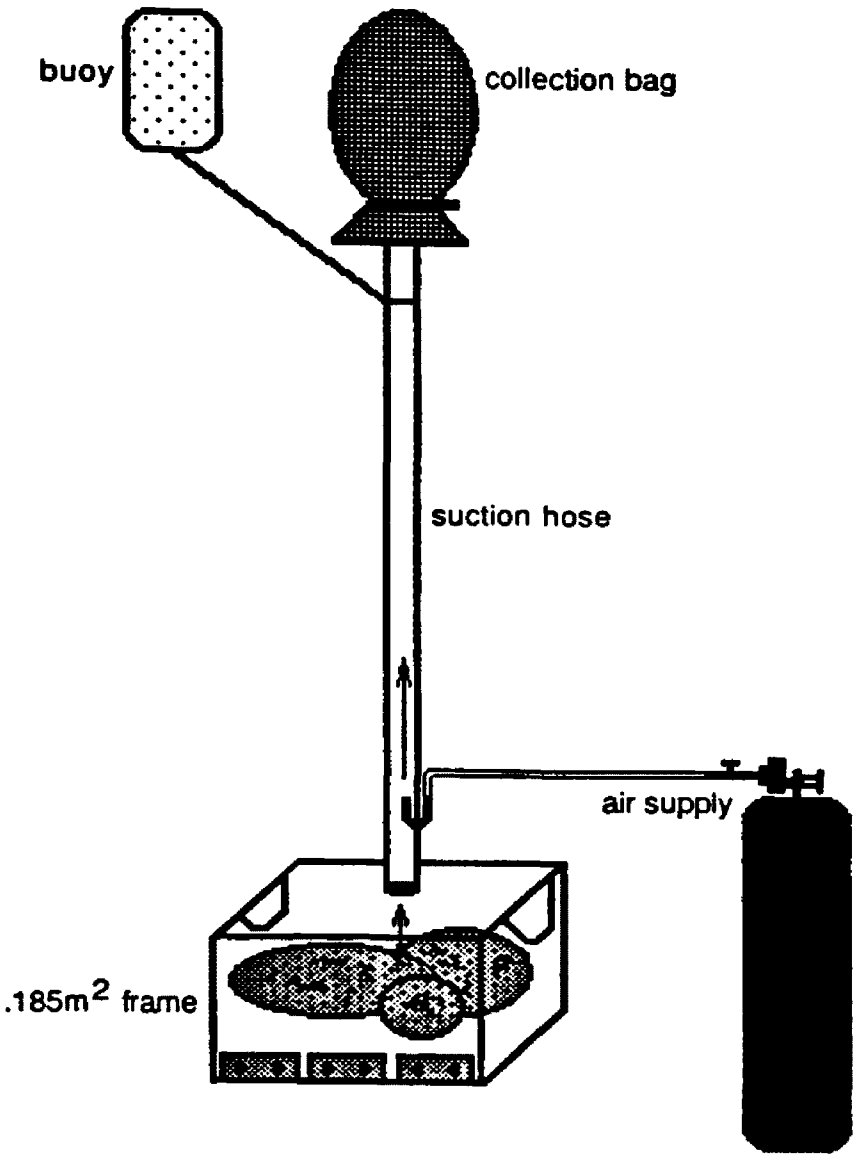

Figure I.3 Air-lift sampler used to collect macroinvertebrates from rocky substrate.

instars of mayflies and caddisflies. Organisms were identified to the lowest practical taxonomic level using Merritt and Cummins (1984), Pennak (1989), and Wiggins (1977).

Benthic organic matter

Quantitative measurements of benthic organic matter were estimated in the littoral zones of both lakes during August. Autochthonous material (periphyton) was analyzed in both lakes; however, allochthonous material (primarily leafy and woody debris) was undetectable by sight in Flathead Lake bottom samples and therefore, was measured in Lake McDonald only.

Periphyton was scraped (25cm^2 area) with a razor blade from five randomly chosen cobbles in each zone of the two lake sites. Periphyton samples were preserved in 125ml bottles (70% ethanol) for gravimetric analysis. Periphyton samples were retained on Gelman Type A/E glass-fiber filters and oven-dried at 105°C to a constant dry weight then ashed at 550°C for one hour to obtain g/m^2 ash-free dry weight (AFDW).

Fractions (1/4-3/4 of entire sample) of organic matter collected in Lake McDonald air-lift samples, which remained after the removal of most invertebrates, were used for the analysis of allochthonous material (size fraction 150µm-2mm). Sample were oven-dried at 70°C to a constant dry weight and then ashed at 550°C for one hour. Mean allochthonous material (AFDW) was estimated by

subtracting mean periphyton AFDW collected in each of the respective sampling regions.

Macrobenthic comparisons

Various comparisons were made between the macrobenthos of the two study lakes including taxa richness, community composition, taxonomic abundance, and trophic structure. For taxa richness, the identification level varied from the family level to the species level, but individual taxonomic levels remained consistent for comparisons between lakes.

Functional feeding groups of insect and non-insect taxa were compared between the two study lakes. Insect feeding groups were separated into two habitat-preference categories based on descriptions by Merritt and Cummins (1984) and others (Table I.2). The categories included: 1) insects which prefer a more depositional-type aquatic environment and are uncommonly found in erosional-type environments; and 2) insects which prefer a more erosional-type environment but are sometimes found in depositional regions as well. This categorization helped separate the effects of substratum preference which varied with depth in the two study lakes and allowed for easier comparison of the distribution and abundance of trophic groups. The functional feeding group system has been widely accepted among benthologists for making generalizations about macroinvertebrate assemblages (Lamberti and Moore, 1984; Merritt and Cummins, 1984). However, it must be noted

that limitations do exist when using this classification owing to possible changes in food availability, feeding strategies related to life stages, or the taxonomic aggregation used in defining groups.

Statistical Analyses:

Differences in macrobenthos abundance, in terms of taxonomic groups and trophic guilds (i.e. feeding groups) of the two habitat-types (i.e. erosional or depositional), were examined between the two lakes using nested and split plot analysis of variance (ANOVA). ANOVA's were performed using square root-transformed mean seasonal abundances (n=2 sites/lake/date). Nested ANOVA's (SITE nested under LAKE) compared differences between the varial zones of the two lakes using summer samples only due to natural dewatering of the Lake McDonald varial zone. Split plot ANOVA's compared differences between the permanently wetted zones of the two lakes using the transformed means of all three sampling dates. If the split plot ANOVA revealed the interaction term LAKE*DATE significant ($P<0.1$) using DATE*SITE{LAKE} as the ERROR term, then a model was created to test significant differences between lakes for each separate date: the F-ratio numerator was MEAN SQUARE SITE{LAKE} from the MODEL y=CONSTANT + LAKE + SITE{LAKE} and the F-ratio denominator was MEAN SQUARE LAKE from the MODEL y=CONSTANT + LAKE + DATE + LAKE*DATE + SITE{LAKE} + DATE*SITE{LAKE}.

ANOVA's for each sampling zone were performed using SITE as a fixed factor (F-ratio=MEAN SQUARE LAKE/MEAN SQUARE ERROR) and SITE as a random factor (F-ratio=MEAN SQUARE LAKE/MEAN SQUARE SITE{LAKE}). The first calculation, using SITE as a fixed factor, was performed to make inferences strictly between the two entire 60m lake regions sampled for each zone. The latter calculation, using SITE as a random factor, accounted for variation between the two 30m sites within each lake to make inferences between the entire rocky littoral zones of the two lakes. Significance levels were reported for both inference statements for each sampling zone: "Sites" indicated P-values strictly between entire 60m lake regions sampled for each zone and "Lakes" indicated the P-values between entire rocky littoral zones of the two lakes. P-values greater than 0.1 were considered insignificant.

RESULTS

Benthic organic matter

A marked difference was observed in the quantity and composition of benthic organic matter collected in the rocky littoral zones of the two lakes (Figure I.4). Flathead Lake benthic organic matter was composed of autochthonous material (periphyton) which was 1.5-5.7 times greater in Flathead Lake (7.0-27.4g/m^2) than Lake McDonald (4.8-5.7g/m^2). However, allochthonous material (primarily leafy and woody debris) was estimated at 15.8-23.9g/m^2 AFDW in Lake McDonald but was undetectable in Flathead Lake samples.

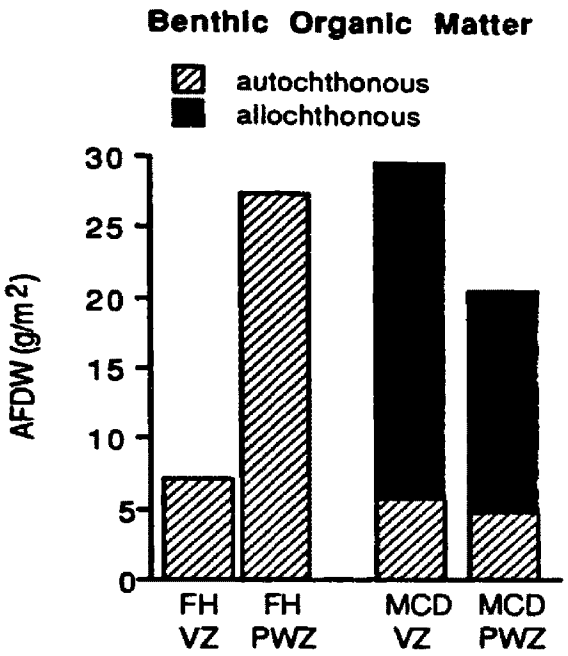

Figure I.4 Benthic organic matter (AFDW g/m^2) in the varial zone (vz) and permanently wetted zone (pwz) of Flathead Lake (FH) and Lake McDonald (MCD) during August 1991. Allochthonous material size fraction<2mm.

Taxa richness

A total of 44 taxa was collected from the two study lakes (Table I.2), of which 29 taxa were present in both lakes. Five taxa were found exclusively in regulated Flathead Lake, including abundant (50-100/m^2) to very abundant (>100/m^2) Heptageniidae (*Heptagenia* sp. and *Stenonema* sp.), one common (10-50/m^2) Lymnaeidae (*Stagnicola elrodii*), and two rarely occurring (<5/m^2) Trichoptera (*Psychoglypha* sp. and *Molanna* sp.). Ten taxa were found exclusively in unregulated Lake McDonald, including one abundant Coleoptera (*Dubiraphia* and other Elmidae sp.), four uncommon (5-10/m^2) taxa (*Limnephilus* sp., *Suwallia* sp., *Promentus* sp., and Corixidae) and five rare taxa (*Amphicosmoecus canax*, *Anabolia* sp., *Clistoronia* sp., *Siphlonurus* sp., and *Ophiogomphus* sp.).

Community composition and abundance

Chironomidae dominated the benthic fauna of both study lakes, comprising 63-93% of the total organisms collected from both regions of the littoral zones (Figure I.5). Chironomid densities were similar between the varial zones of both lakes, but twice as many Chironomidae were present in the permanently wetted zone of regulated Flathead Lake compared to unregulated Lake McDonald (Figure I.6; Sites: $P<.001$; Lakes: $P=.099$).

The portions of remaining taxa were similar between the varial zones of both lakes with the exception of Plecoptera which represented 7% of the Lake McDonald varial zone benthos but only

Table I.2 Mean seasonal abundance (± standard error) of benthic macroinvertebrates collected in the varial zone and permanently wetted zone of Flathead Lake and Lake McDonald. Sp=spring, Su=summer, Au=autumn.

	Varial Zone			Permanent Wet Zone			
	Flathead Lake (Summer) n=2	Flathead Lake (Autumn) n=2	Lake McDonald (Summer) n=2	Flathead Lake (Sp,Su,Au) n=6	Lake McDonald (Sp,Su,Au) n=6	Feeding References+	Habitat References++
Shredders/CPOM Detritivores							
INSECTA							
Erosional/Depositional							
Capnia confusa	36 (36)	14 (14)	189 (77)	1 (1)	7 (4)	7,10	7
Lepidostoma	56 (56)	9 (9)	81 (49)	1 (1)	17 (7)	7,9	7
Limnephilus	0	0	0	0	5 (3)	7	7
Amphicosmoecus canax	0	0	1 (1)	0	0	7	7
Depositional							
Anabolia	0	0	0	0	1 (1)	7	7
Grazers							
INSECTA							
Erosional/Depositional							
Stenonema	32 (31)	156 (32)	0	13 (7)	0	7	7
Heptagenia	35 (32)	69 (12)	0	3 (2)	0	7	7
Leucrocuta	2 (2)	0	19 (2)	0	20 (9)	7	7
Apatania	0	0	8 (1)	7 (2)	12 (7)	6,7,9	7
Depositional							
Hydroptila	2 (2)	3 (2)	0	15 (6)	25 (22)	7,9	11
Molanna	0	0	0	1 (1)	0	7,9	11
Elmidae (*Dubiraphia* & other sp.)	0	0	8 (4)	0	90 (31)	2	2
GASTROPODA							
Stagnicola	51 (45)	38 (31)	0	41 (13)	0	8	
Physella	34 (34)	5 (4)	81 (32)	2 (2)	9 (3)	8	
Gyraulus	6 (1)	24 (16)	1 (1)	21 (6)	43 (12)	8	
Helisoma anceps	0	0	0	3 (2)	1 (1)	8	
Promenetus	0	0	0	0	9 (4)	8	
Valvata humeralis	0	0	0	1 (1)	1 (1)	8	
Collectors/FPOM Detritivores-Herbivores							
INSECTA							
Erosional/Depositional							
Paraleptophlebia	310 (205)	330 (256)	264 (77)	8 (5)	97 (35)	3,7	7
Ameletus	137 (107)	21 (16)	25 (25)	1 (1)	12 (9)	3,7	7
Centroptilum	0	0	14 (4)	1 (1)	1 (1)	3,7	7
Ceraclea	36 (28)	4 (4)	1 (1)	12 (4)	1 (1)	9	7
Psychoglypha	1 (1)	0	0	0	0	9	7
Depositional							
Chironomidae*	1900 (511)	377 (**)	1760 (309)	11552 (1192)	5402 (580)	7	7
Caenis	0	0	10 (4)	27 (20)	32 (16)	7	7
Leptophlebia	0	0	0	7 (3)	11 (9)	7	7
Ephemera simulans	0	0	1 (1)	17 (5)	10 (10)	7	7
Siphlonurus	0	0	0	0	1 (1)	7	7
Mystacides	1 (1)	0	8 (2)	4 (2)	11 (4)	7	7
Oligotricha	0	0	0	0	1 (1)	7	7
AMPHIPODA							
Hyalella azteca	43 (27)	19 (6)	196 (107)	588 (65)	48 (19)	5,8	8
Gammarus lacustris	190 (124)	50 (14)	102 (20)	46 (24)	8 (4)	8	8
Predators							
INSECTA							
Erosional/Depositional							
Oecetis	5 (1)	29 (23)	4 (4)	11 (2)	8 (3)	7,9,11	7
Dytiscidae	4 (1)	0	24 (14)	0	8 (2)	7	7
Corixidae	0	0	2 (1)	0	7 (3)	7	7
Sweltsa	0	0	7 (5)	0	3 (2)	7	7
Depositional							
Tanypodinae	59 (16)	81 (**)	15 (10)	254 (20)	224 (34)	7	7
Ceratopogonidae	0	0	8 (8)	4 (2)	1 (1)	7	7
Polycentropus	13 (9)	1 (1)	0	21 (6)	23 (6)	6,7,9	9
Nyctiophylax	0	0	0	8 (4)	3 (1)	7,9	8
Ophiogomphus	0	0	1 (1)	0	1 (1)	7	7
HIRUDINEA							
Nephelopsis obscura	13 (11)	7 (5)	11 (5)	3 (1)	2 (1)	8	
Helobdella stagnalis	0	0	0	3 (2)	1 (1)	8	
Glossiphonia complanata	0	0	1 (1)	1 (1)	1 (1)	8	

*Excluding Tanypodinae. ** Average from one site only. +,++References: 1-Arens (1989), 2-Brown (1987), 3-Edmunds et al. (1976), 4-Gilpin and Busvens (1970), 5- Hargrave (1970), 6-Hynes (1970), 7-Merritt and Cummins (1984), 8-Pennak (1989), 9-Wiggins (1977), 10-Stewart and Stark (1988), 11-Personal observation

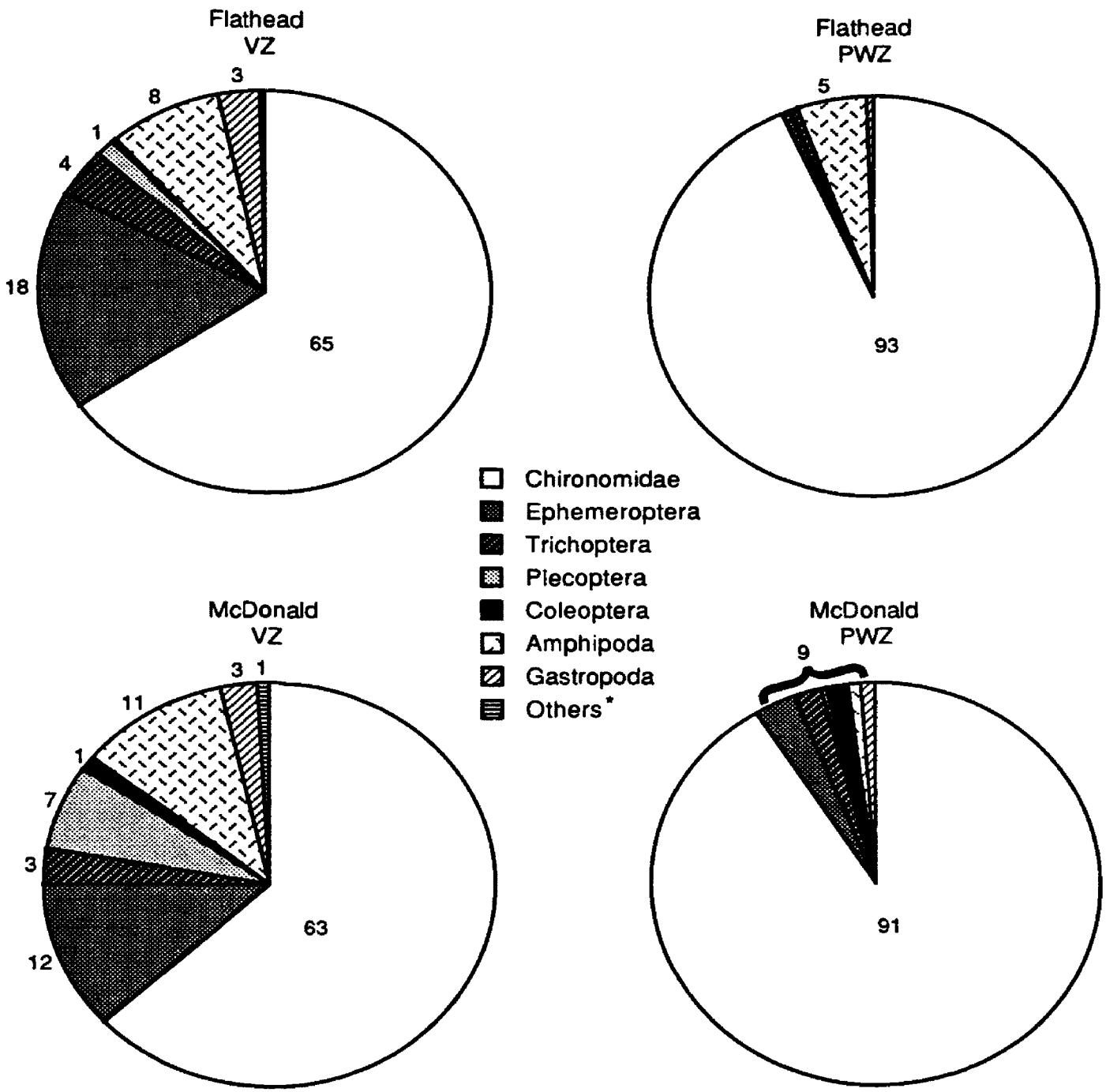

Figure I.5. Percent composition of major taxa in the varial zone (VZ) and permanently wetted zone (PWZ) of Flathead Lake and Lake McDonald; *Others includes Hirudinea, Hemiptera, Ceratopogonidae, and Odonata.

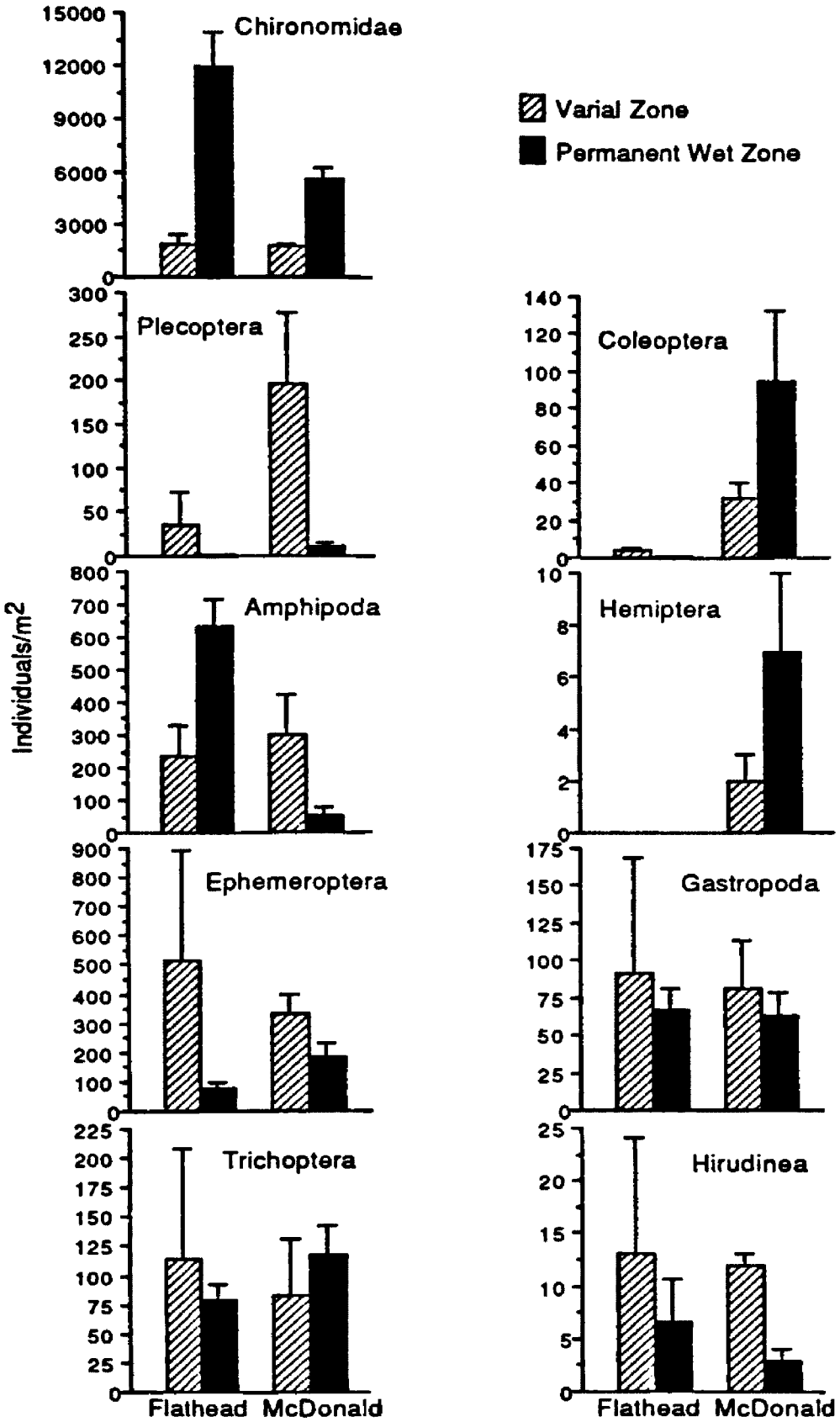

Figure I.6 Mean abundance (± standard error) of major taxonomic groups in the varial zone (summer only, n=2 for 2 sites/lake) and permanently wetted zone (mean of spring, summer, and autumn, n=6 for 2 sites/lake & 3 sampling dates) of Flathead Lake and Lake McDonald.

1% of the Flathead Lake varial zone benthos (Figure I.5). Almost 200/m^2 (*Capnia confusa* and *Suwallia*; Table I.2) were collected in the varial zone of Lake McDonald; only 36/m^2 *Capnia confusa* were collected in the varial zone of Flathead Lake during summer (Figure I.6; Sites: P=.001; Lakes: P=.20). Plecoptera abundance in the varial zone of Flathead Lake remained low (14/m^2; Table I.2) during autumn.

Of the remaining benthos in the permanently wetted zones, Amphipoda (primarily *Hyalella azteca;* Table I.2) comprised 5% of the community of Flathead Lake while a variety of Ephemeroptera, Trichoptera, Coleoptera, and Gastropoda comprised 8% of the Lake McDonald permanently wetted zone community (Figure I.5). Amphipoda density was 13 times greater in the permanently wetted zone of Flathead Lake compared to Lake McDonald (Figure I.6; Sites: P=.004; Lakes: P=.01). Furthermore, mean densities of Ephemeroptera, Trichoptera, and Coleoptera were lower in the permanently wetted zone of Flathead Lake than Lake McDonald (Figure I.6).

Coleoptera (Dytiscidae and Elmidae; Table I.2) were scarce or absent from Flathead Lake samples (<5/m^2) compared to a mean density of 128/m^2 in Lake McDonald (Figure I.6; Varial Zone, Sites: P=.71, Lakes: P=.02; Permanent Wet Zone, Sites: P=.04, Lakes: P=.03). Hemiptera were absent from Flathead Lake samples but occurred in low densities (<10/m^2) in Lake McDonald (Figure I.6; Varial Zone, Sites: P=.21, Lakes: P=.21; Permanent Wet Zone, Sites: P=.28,

Lakes:P=.05). Gastropoda and Hirudinea abundances and distributions were similar between the two study lakes (Figure I.6). Pelecypoda, Hydracarina, Planaria, Oligochaete, and Polychaete were rare and comprised less than 1% of the total organisms in both lakes.

Trophic structure: Feeding groups which prefer erosional-type habitats

Distinct patterns were observed between the two lakes among the insect shredders, grazers, and collectors in relation to their depth distribution and habitat preference (Figure I.7). Among those insects which prefer a more erosional-type habitat, the varial zone shredders (primarily *Capnia* and *Lepidostoma*; Figure I.8) were 2.7 times more abundant in Lake McDonald compared to Flathead Lake (Sites: P<.001; Lakes: P=.40). Mean shredder density in the permanently wetted zones was also higher in Lake McDonald ($29/m^2$) compared to Flathead Lake ($2/m^2$) for all three seasons (Sites: P=.06; Lakes: P=.03). In contrast to shredders, varial zone grazers and collectors (primarily Heptageniidae, *Paraleptophlebia* sp. and *Ameletus* sp., Figure I.8) were 1.6-2.6 times more abundant in Flathead Lake than in Lake McDonald (Figure I.7; Sites: P<.001; Lakes: P=.79). Additionally, varial zone grazer abundance in Flathead Lake increased by three-fold to $225/m^2$ during autumn. In the permanently wetted zones, grazer densities did not differ between the two study lakes for all three seasons (Sites: P<.001; Lake: P=.76); collector densities were similar during spring but increased in Lake McDonald during summer and autumn (Sites: P=.003; Lakes:

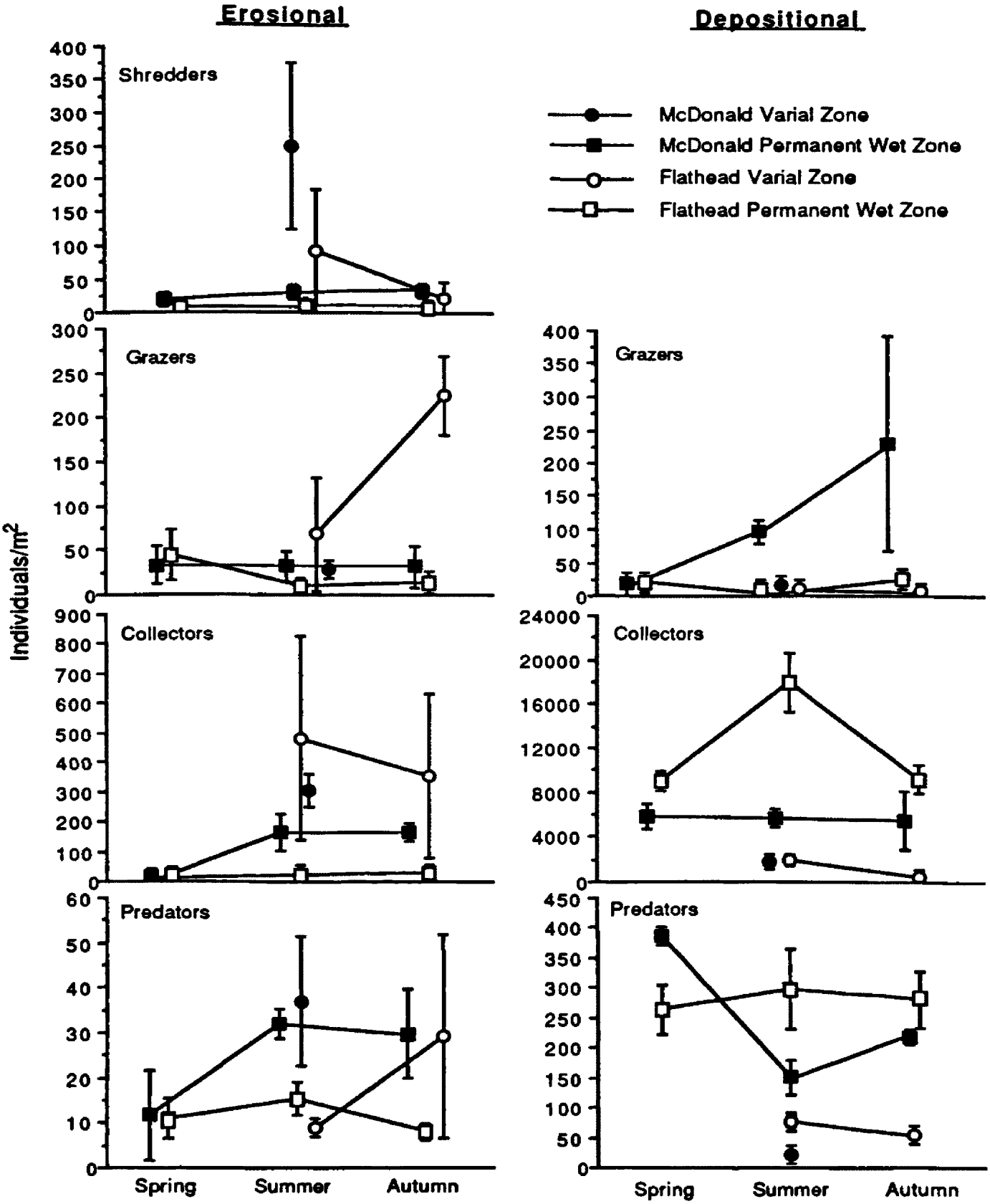

Figure I.7. Mean seasonal abundance of insect functional feeding groups in the varial zone and permanently wetted zone of Flathead Lake and Lake McDonald; Insects are separated by habitat preference: erosional-type (left) or depositional-type (right) habitat; Values shown are means ± standard error, n=2 for 2 sites/lake).

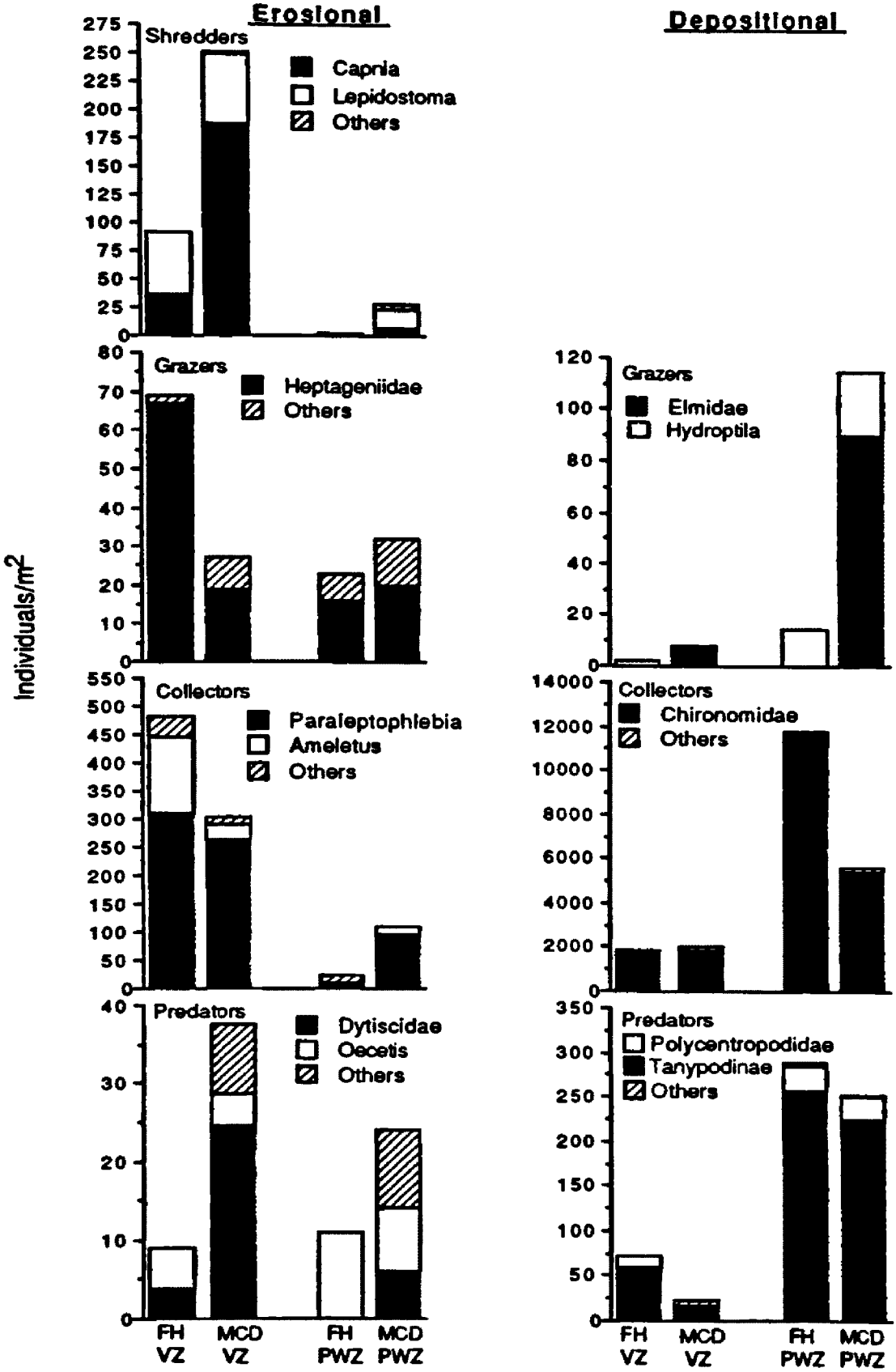

Figure I.8 Mean abundance of dominant taxa in each of the insect functional feeding groups of the Flathead Lake (FH) and Lake McDonald (MCD) varial zone (VZ; mean of summer only) and permanently wetted zone (PWZ; mean of spring, summer, and autumn).

P=.12). In general, predator abundance was three times higher in both zones of the unregulated lake during summer and autumn (Varial Zone, Sites: P=.19, Lakes: P=.12; Permanent Wet Zone, Sites: P=.05, Lakes: P=.21) with the exception of a three-fold increase in varial zone predators (*Oecetis*; Table I.2) in Flathead Lake (Figure I.7) during autumn. Dytiscidae and *Oecetis* sp. (Trichoptera) dominated the predator group in Lake McDonald and Flathead Lake, respectively (Figure I.8).

Trophic Structure: Feeding groups which prefer depositional-type habitats

In the permanently wetted zones, which provided depositional-type environments during full pool, grazer abundance of Flathead Lake remained fairly low (<25/m^2) while Lake McDonald grazer densities increased up to 115/m^2 during autumn (Figure I.7; Sites: P<.001; Lakes: P=.21). *Hydroptila* sp. (Trichoptera) were dominant among the Flathead Lake grazers; *Dubiraphia* sp. and other Elmidae were dominant among the Lake McDonald grazers (Figure I.8). In contrast to grazers, collector densities (primarily Chironomidae; Figure I.8) remained comparatively low (5,657/m^2) in the permanently wetted zone of Lake McDonald; Flathead Lake collectors reached a maximum density of 17,927/m^2 during summer in the permanently wetted zone (Figure I.7; Sites: P<.001; Lakes: P=.097). Grazer and collector densities in the varial zones were similar between the two lakes. Predator distributions, primarily Tanypodinae and Polycentropodidae (Figure I.8), were also similar

between the two lakes with higher densities occurring in the permanently wetted zones of both lakes (Figure I.7).

Trophic grouping of non-insect benthos

Gastropoda species composition and habitat preference varied greatly between lakes and depth zones and thus no patterns could be discerned (Figure I.9). However, Amphipoda (collectors), dominated by *Hyalella azteca*, were distributed similarly to the collectors (Insecta) which preferred depositional-type habitats; significantly higher Amphipoda densities were found in the permanently wetted zone of Flathead Lake (Sites: P=.004; Lakes P=.01). *Hyalella azteca* generally prefers a more depositional-type environment with finer sediments (Hargrave, 1970). Hirudinea (predators), primarily *Nephelopsis obscura*, were low in abundance and densities varied greatly within and between the two study lakes (Figure I.9).

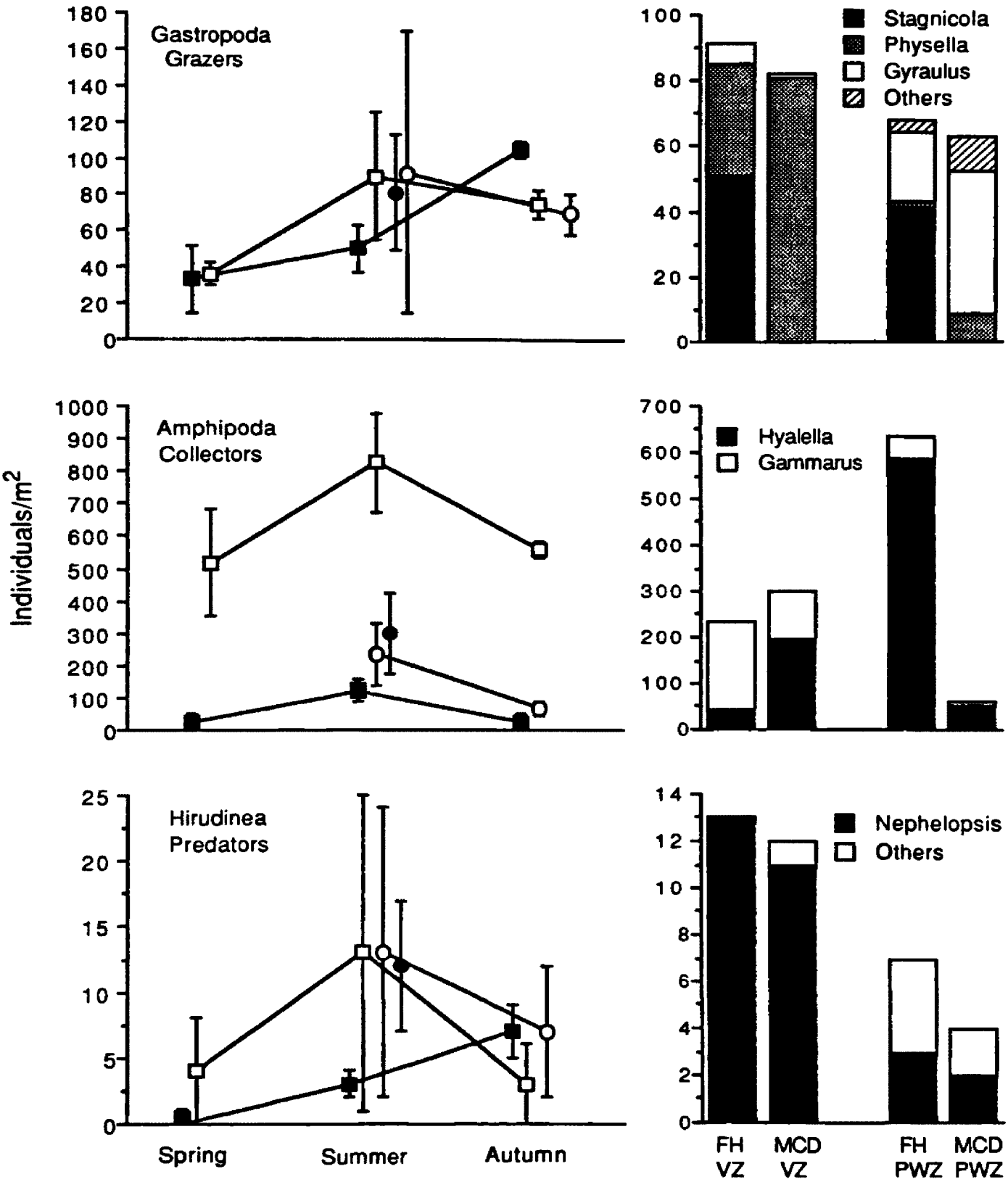

Figure I.9. Mean abundance of non-insect functional feeding groups (left); Mean abundances of dominant taxa of each group (right) in Flathead Lake (FH) and Lake McDonald (MCD) varial zone (VZ) and permanently wetted zone (PWZ); Values shown (left) are means ± standard error, n=2 (2 sites/lake).

DISCUSSION

Altered lake-level fluctuations did not appear to have an adverse impact on total abundance of macrozoobenthos residing in the shallow (<5m depth) rocky littoral zone of Flathead Lake within the study sites. Density estimates of total invertebrates in the littoral zone of Flathead Lake were similar to or even greater than those of reference Lake McDonald during August 1990 (Varrelman and Spencer, 1991) and August 1991 (Figure I.10). However, the artificial retention of high water-levels followed by gradual winter drawdown did appear to influence the composition, abundance, and distribution of certain benthic fauna owing to changes in food sources and substratum.

The maximum elevation of Flathead Lake is maintained 4-6 months beyond the natural full-pool season, resulting in increased erosion upon the shoreline and within the varial zone (Lorang et al., *in press*). Heavy windstorms are frequent on Flathead Lake, especially during late autumn-early winter and water-levels remain unnaturally high. Thus, extensive wave action in the nearshore environment has resulted in the loss of some riparian vegetation and increased transport of coarse particulate organic matter (CPOM) upon the beach face (Lorang et al., *in press*) making it less available for aquatic organisms. The loss of CPOM may adversely impact the benthic invertebrates which utilize this material for food, case-building material, refuge from predators, and oviposition and emergence sites.

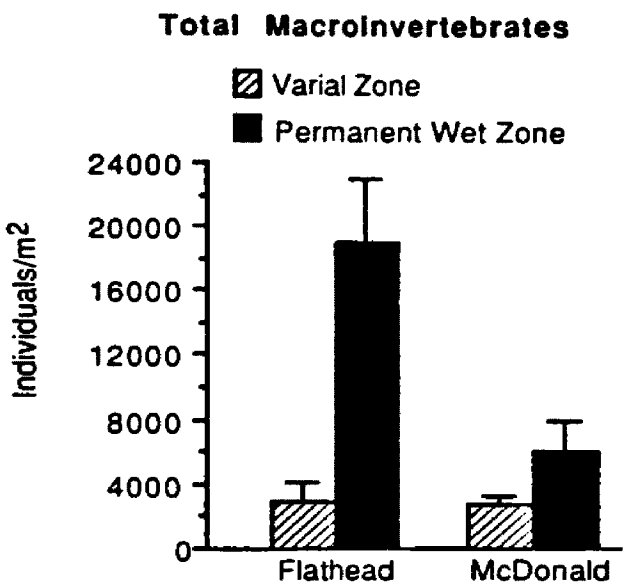

Figure I.10. Mean abundance of total benthos in Flathead Lake and Lake McDonald during August 1991; Values shown are means ± standard error, n=2 (2 sites/lake).

Benthic shredders, such as *Capnia confusa* and *Lepidostoma* sp., generally rely on decaying leafy or woody material for direct consumption or feeding upon biofilm-rich surfaces (Anderson et al., 1984; Dudley and Anderson, 1982; Stewart and Stark, 1988). Thus, lower mean densities of shredders in the littoral zone of Flathead Lake, although not statistically significant, may be related to the loss or riparian vegetation and allochthonous CPOM. The altered fluctuation regime of Flathead Lake does allow direct leaf input into the inundated varial zone during autumn. However, many of these leaves float on the lake surface and subsequently are washed onto the exposed beach face before they have a chance to become hydrated and sink. In contrast, autumnal leaf litter present along the dewatered varial zone of Lake McDonald may be leached by spring snow melt, conditioned by bacteria, and sink to the bottom of the inundated varial zone; thus providing a food source and cover for benthos such as *Capnia confusa*.

The availability of terrestrial plant material in an aquatic environment also may ultimately control the success of certain case-building Trichoptera (Minshall, 1984). For instance, Trichoptera which construct cases from minerals occurred in similar densities between the two study lakes; Trichoptera which construct cases from plant material were three-four times more abundant in Lake McDonald than Flathead Lake (Figure I.11).

Small particles of woody material may provide substratum which is more suitable for diving/clinging-type fauna such as

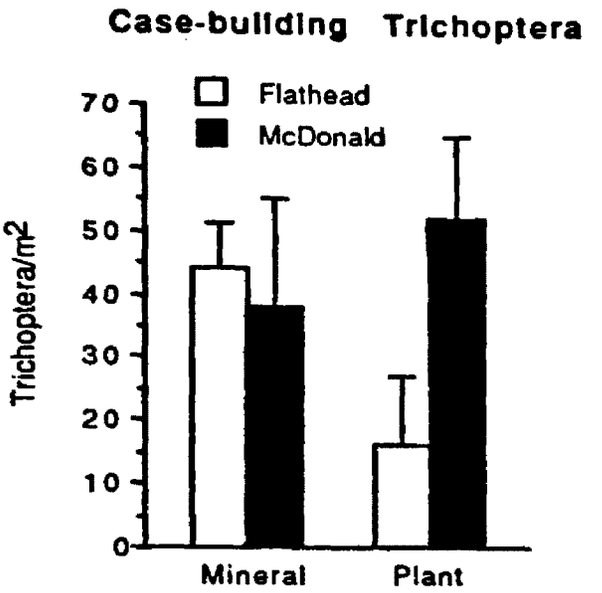

Figure I.11 Mean abundance (± standard error) of Trichoptera which construct cases from minerals or plant fragments in the littoral zone of Flathead Lake and Lake McDonald.

Elmidae, Corixidae, and Dytiscidae. These aquatic beetles and hemipterans rely on the presence of substratum they can easily cling to in order to maintain neutral buoyancy for grazing on algae, seeking prey, or avoiding predation (Brown 1987; Ward 1992). Elmidae, Dytiscidae, and Corixidae occurred more commonly in Lake McDonald where more woody substratum was available than in Flathead Lake.

Flathead Lake and Lake McDonald are both considered oligotrophic lakes (Stanford et al., 1983; Ellis et al., 1991). However, Flathead Lake receives greater nutrient inputs which act synergistically with the altered fluctuation regime to increase littoral periphyton productivity (Bauman, 1988). The artificial retention of high water-levels allows ample time and optimal conditions for periphyton growth in the varial zone. Furthermore, the weathered biofilm exposed to winter desiccation is capable of rapid production upon rewetting owing to protected filaments on the undersides of rocks (Bauman, 1988) and the potential release of nutrients from the decayed portion. The presence of two highly abundant grazer mayflies, *Heptagenia* sp. and *Stenonema* sp., in the varial zone of Flathead Lake appeared to be a positive response to enhanced periphyton. Additionally, collectors which preferred a more erosional-type habitat were 1.6-2.6 times more abundant, although not statistically significant, in the varial zone of Flathead Lake compared to Lake McDonald. These collectors were dominated by *Paraleptophlebia* sp. and *Ameletus* sp. nymphs which feed on

diatoms and decaying fine particulate organic matter (FPOM) apparently derived from autochthonous sources.

Regulation has also caused a redistribution of smaller sediments in the littoral zone of Flathead Lake. A majority of the sands and smaller gravels which were present in the varial zone prior to regulation had been eroded and redeposited in the offshore permanently wetted region (Lorang et al., *in press*). Additionally, present windstorms during full-pool continue to cause erosion of finer shoreline sediments which are carried lakeward and deposited. This offshore transport of inorganic substratum appeared to influence the littoral macrobenthos composition and distribution. A more erosional-type habitat, lacking finer inorganic material, is created in the varial zone of Flathead Lake, thus favoring more lithophilous organisms such as *Heptagenia* sp. and *Stenonema* sp.. In contrast, the sprawling mayfly *Caenis* sp. occurred in densities of 10-53/m^2 during 1990 (Varrelman and Spencer, 1991) and 1991 in the varial zone of Lake McDonald but were absent from the Flathead Lake varial zone. *Caenis* nymphs generally prefer rocky substratum covered with a fine layer of silt (Cummins and Lauff, 1969).

The transport of smaller substratum toward deeper parts of lakes implies a deposition of organic material as well to offshore regions (Grimas, 1962). Especially during summer, Chironomidae and *Hyalella azteca* (collectors) were very abundant in the permanently wetted region of Flathead Lake compared to Lake McDonald. Both of these taxa generally prefer the presence of finer sediments for

burrowing and feeding on FPOM (Merritt and Cummins, 1984; Hargrave, 1970).

Autochthonous material in the permanently wetted zone of Flathead Lake was approximately five times greater than in any other regions sampled in both lakes. Prior to regulation, large cobbles in the permanently wetted zone of Flathead Lake were exposed to extensive wave action eight-nine months annually during natural low water-levels. Under regulated conditions, offshore periphyton growth is less limited by scour and thus can grow into a thick "carpet". Furthermore, offshore transport of nutrients contained in fine sediments and organic matter is likely to enhance periphyton growth in the deeper littoral zone. The presence of a thick carpet of biofilm, such as that in the permanently wetted zone of Flathead Lake, is generally unsuitable for offshore grazers. Elmidae grazers (primarily *Dubiraphia* sp.) were absent from Flathead Lake but were very abundant in the permanently wetted zone of Lake McDonald. Furthermore, the deposition of fine sediments within the carpet layer further retards grazing ability.

In addition to alteration of food and substratum, other possible direct consequences of regulated water-levels may account for the reduced abundance or absence of *Capnia confusa* and Elmidae in Flathead Lake. Unlike many other regulated lakes studied which experience rapid fluctuations, the winter dewatering of the Flathead Lake varial zone is a gradual process which occurs over a six-month period (October-March). Thus, it is likely that motile forms will

migrate with declining water levels, but non-motile stages (pupae and eggs) of certain taxa may become dewatered and subject to desiccation and/or freezing. For instance, *Capnia confusa* emerge during late winter/early spring (February-May) (Stanford, 1975), and the early emerging females are likely to oviposit along the shallow waters. Consequently, these eggs may become stranded in the dewatered sediment as lake-levels continue to recede through March.

Elmidae also undergo a non-motile pupal stage. This pupal stage, which requires moist areas in soils, under rocks, or rotting wood, occurs during late spring-summer (Brown, 1987). Perhaps Elmidae rely on summer dewatering to utilize moist, protected regions of the varial zone for pupation. Certain Elmidae species residing in fluctuating streams are known to pupate in recently dewatered sediments as water-levels recede (Brown, 1987). The extended full-pool period of Flathead Lake may interrupt this part of the Elmidae life cycle.

Finally, the possibility exists that factors other than regulation play a significant role in structuring macroinvertebrate composition, abundance, and distribution in Flathead Lake. For instance, snails (grazers) did not exhibit the expected distribution pattern of increased abundance in the varial zone of Flathead Lake as did the erosional-type grazers (Insecta). *Orconectes virilis* (crayfish), a major predator of snails (Hanson et al., 1990), is present in Flathead Lake and may have influenced the snail community composition and distribution.

The high amount of variability observed within the study lakes may be related to factors such as differences in wind/wave exposure (Dall et al., 1984), proximity to ground water inputs, or angularity of substratum (Krecker and Lancaster, 1933). However, despite this variability, certain patterns in nearshore benthic abundance, composition and distribution were distinguishable between regulated Flathead Lake and unregulated Lake McDonald.

SUMMARY AND CONCLUSIONS

In conclusion, water-level regulation appeared to influence the balance between the dominant groups and abundance of certain species in Flathead Lake even after 50 years of regulation.

Prolonged wave action caused shoreline erosion, including loss of riparian vegetation and transport of woody and leafy materials onto the beach away from the lake environment. This apparently caused a decrease in abundance of shredders, plant-case building caddisflies, and diving/clinging-type fauna in Flathead Lake.

The extended full-pool period, coupled with greater nutrient inputs, enhanced periphyton growth in the varial zone of Flathead Lake and thus, promoted abundance of nearshore collectors and grazers (Insecta).

The lakeward transport of finer inorganic sediments and the presence of a thick periphyton "carpet" in the offshore littoral zone of Flathead Lake provided suitable habitat for Chironomidae and *Hyalella azteca*. However, this periphyton mat seemed unfavorable to

grazers (Insecta) and limited the diversity and abundance of Trichoptera and Ephemeroptera.

Finally, life stages of *Capnia confusa* and Elmidae may likely be directly affected by the altered season of fluctuation owing to desiccation of eggs (*Capnia*) or insufficient habitat for pupation (Elmidae).

II. CHAPTER TWO: A BENTHIC AIR-LIFT SAMPLER SUITABLE FOR LARGE COBBLE SUBSTRATUM

INTRODUCTION

Quantitative sampling of lentic macrozoobenthos from large cobble substratum (>10cm diameter) at depths greater than one meter presents a challenging task to benthologists. Conventional devices such as dredges, corers, or grab samplers are ineffective in regions with large substratum. A variety of air-lift and suction samplers have been designed to sample heterogeneous substratum (Drake and Elliott, 1982; Elliott and Tullett, 1978). However, many of these samplers have limitations including: small sample area, sample shallow (<1m) depths only, or sample flat bottoms only (Boulton, 1985; Brown et al., 1987; Mackey, 1972; Pearson et al., 1973).

A recent study comparing the macrozoobenthos of two northwestern Montana lakes required the collection of quantitative samples along large-cobble regions at varying depths (1.5-4.5m) and bottom slopes. Furthermore, it was necessary to operate the sampler independent of a boat owing to frequent wave action on the two lakes. This paper presents the construction and operation of an air-lift sampler which was designed for this purpose. Performance of the air-lift sampler was evaluated by efficiency tests and by comparing the air-lift sampler to traditional rock basket samplers.

METHODS

Construction and operation

The air-lift device (Figure II.1) was operated by one SCUBA diver. Compressed air was fed into the lower end of a hose which was suspended vertically in the water column. As the air and displaced water rose to the top of the hose, a vacuum was created, thus lifting benthic material and organisms into a mesh bag floated on the lake surface. Design of this air-lift device was similar to those described by Aarefjord (1972) and Kangas and Hallfors (1974); however, it was different in that a tapered mesh collection bag was used, and the sampling frame was open at the top to allow easier handling of large cobbles.

The entire air-lift apparatus, which can be assembled in a day, consisted of three main parts: compressed air (SCUBA) tank (a), 26mm diameter reinforced suction hose (f), and mesh collection bag (h) (Figure II.1). A first stage regulator (b) was attached to the tank and was fitted with an additional 200 psi valve (c) to allow fine adjustment of the air supply. A 7mm diameter polyethylene hose (d) fed air into the suction hose approximately 15cm from the lower end. A 7cm piece of 7mm diameter U-shaped copper tubing (e) directed air flow towards the upper end of the suction hose. The suction hose was suspended vertically in the water column with a buoy (i) attached near the mesh bag. The length of the suction hose exceeded the sampling depth by 25-50cm in order to float the bag at

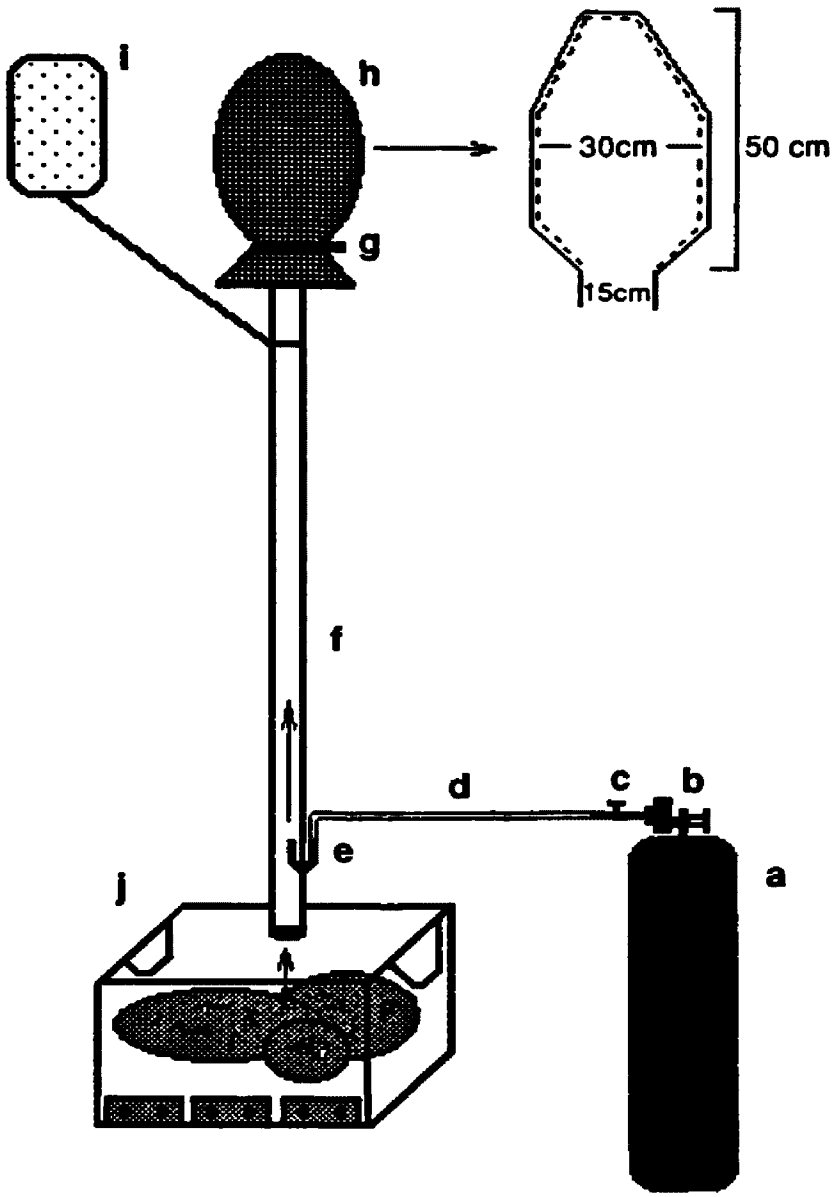

Figure II.1. Schematic diagram of air-lift sampler with 0 .185 m^2 sampling frame.

the surface. A short (2m) submerged hose worked effectively at depths approximately 5m, but it was difficult to maintain diver buoyancy.

The collection bag was made of 150μm Nitex® mesh. Two pieces of mesh were cut into the dimensions shown in Figure II.1, and the seams were sewn with double stitch and sealed with Aquaseal®. The tapered end at the top of the bag facilitated the transfer of sample into a preservation jar. The sample was concentrated into a ball at the top end of the bag and carefully turned inside out to push contents into a sample jar. The bag was attached "seams out" during use for easier cleaning. A hose clamp (g) lined with 9mm closed-cell foam was used to secure the collection bag to the upper end of the suction hose.

Individual samples were collected within a metal frame which enclosed a bottom area of 0.185m^2 and had sides 30cm in height (Figure II.1). Six 1kg lead bars were bolted to the bottom of the frame to help prevent movement while sampling in wavy and steeply sloped regions. To begin the sampling process, the frame was placed on the bottom with the air supply tank positioned within reach. Once the air supply was on and adjusted to the proper suction power, a standardized procedure was followed for each sample collection. Starting in the upper left corner of the sampling frame, all benthos and organic matter were quickly vacuumed from the exposed surfaces of the topmost cobble. The cobble was then lifted from the bottom in order to vacuum smaller substratum underneath to a depth

of about 1cm. The displaced cobble was vacuumed once again on all sides and replaced to its original position or outside the sample area. The procedure was repeated in a clockwise direction until the entire delineated sample area was vacuumed. Sampling time remained constant at 5-6 minutes for each sample. Tank pressure was reduced by approximately 90-95 psi/minute during sampler operation. At the end of sampling each delineated area, the air-supply was shut off and the lower end of the suction hose was quickly hand-capped to prevent loss of benthic material. The diver returned to the surface and inverted the hose to retain all contents into the collection bag. Extra collection bags and a nut-driver were kept handy for changing bags easily at the surface. Full bags were tied shut and given to an assistant or temporarily stored on the lake bottom.

Air-lift efficiency

Air-lift efficiency was tested at a depth of 1.5m in the wave-swept, rocky littoral zone of Flathead Lake. Efficiency was estimated by performing three consecutive removals (5 minutes each) of benthos from a single sample area (0.185m^2). The percentage of organisms captured in the first removal was expressed as a percent of the total number of organisms captured in all three removals. A total of three trials were run and mean percentages were computed for organisms captured in the first, second and third removals. In addition, the total number of consecutive samples needed to completely denude a sample area

($0.185m^2$) was predicted by regressing the logarithm of total macroinvertebrates captured in each consecutive removal against sample (removal) number.

Comparison to basket samplers

Performance was also evaluated by comparing the air-lift with traditional basket samplers. The wire mesh baskets (30.5cm x 30.5cm x 5cm) were constructed of 6mm mesh galvanized hardware cloth, patterned after Wene and Wickliff (1940) and Stanford and Reed (1974). Each basket sampler contained three layers of pre-rinsed natural substratum (8mm gravels: bottom layer, 4cm gravels: middle layer, and four 10cm cobbles: top layer) which was collected along the shore of the respective study lake. Each basket was equipped with a nylon-ripstop enclosure to prevent loss of organisms during retrieval from the lake bottom (Figure II.2).

The air-lift and basket samplers were compared along three different rocky sampling zones: 1) Flathead Lake (1.5m) wave zone, 2) Flathead Lake (4.5m) flat-bottom zone, and 3) Lake McDonald (3.5m) steeply sloped-bottom zone. A 30m transect, paralleling the shore, was established at two different study sites for each of the three sampling zones for a total of six transects. Three basket samplers were placed at 10m intervals along each transect and allowed to colonize for approximately seven weeks. Six air-lift samples were collected randomly along each transect during the period of basket retrieval.

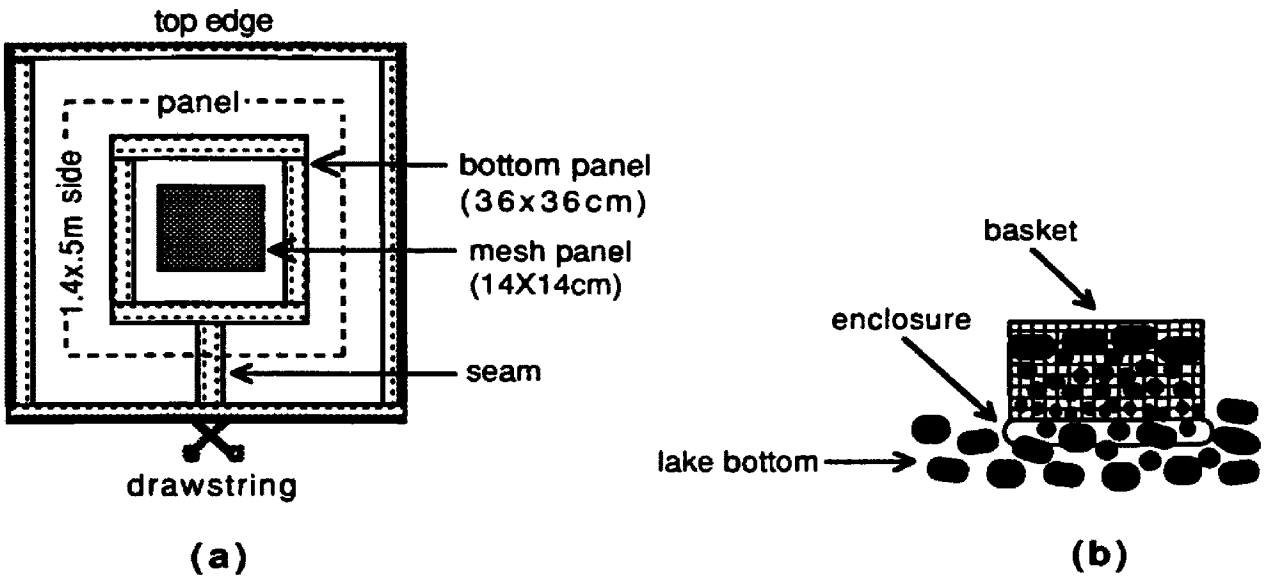

Figure II.2. (a) Top view of nylon enclosure (designed by Alpine Products, Inc., Polson, MT). Excess water is drained from the retrieved basket through the 150µm mesh panel. (b) Basket sampler positioned on lake bottom with enclosure sides rolled down and coverd with existing substrate.

Macroinvertebrate composition and abundance collected by the two samplers were compared. Two-way ANOVA's (factors: SAMPLER and SITE) were performed on taxonomic abundance estimates by the two samplers for each of the three zones. P-values greater than .05 were considered insignificant.

RESULTS AND DISCUSSION

Air-lift operation

The air-lift had sufficient suction power to lift gravels (<10mm diameter) and organisms from a maximum distance of 5cm from the end of the suction hose. In fact, a few 30-40mm length crayfish hiding in rock crevices were unable to escape the air-lift. The sampler did not have efficient lifting power at depths less than one meter. Dumas (1962) and Mackey (1972) describe in detail the relationship between air-lift diameter and sampling depth. The air-lift's power increased with sampling depth and hose length. Thus, it was necessary to adjust airflow to maintain consistent suction power across various sampling depths. Furthermore, it was necessary to use a collection bag with a large enough surface area to prevent clogging and loss of suction power.

Air-lift efficiency

A mean of 71 ± 4.4% (± s.e., n=3) of the total organisms (946) were captured during the first of three consecutive removals from a single sample area (Figure II.3). This efficiency was comparable to a modified Boulton suction sampler (Growns, 1990). However,

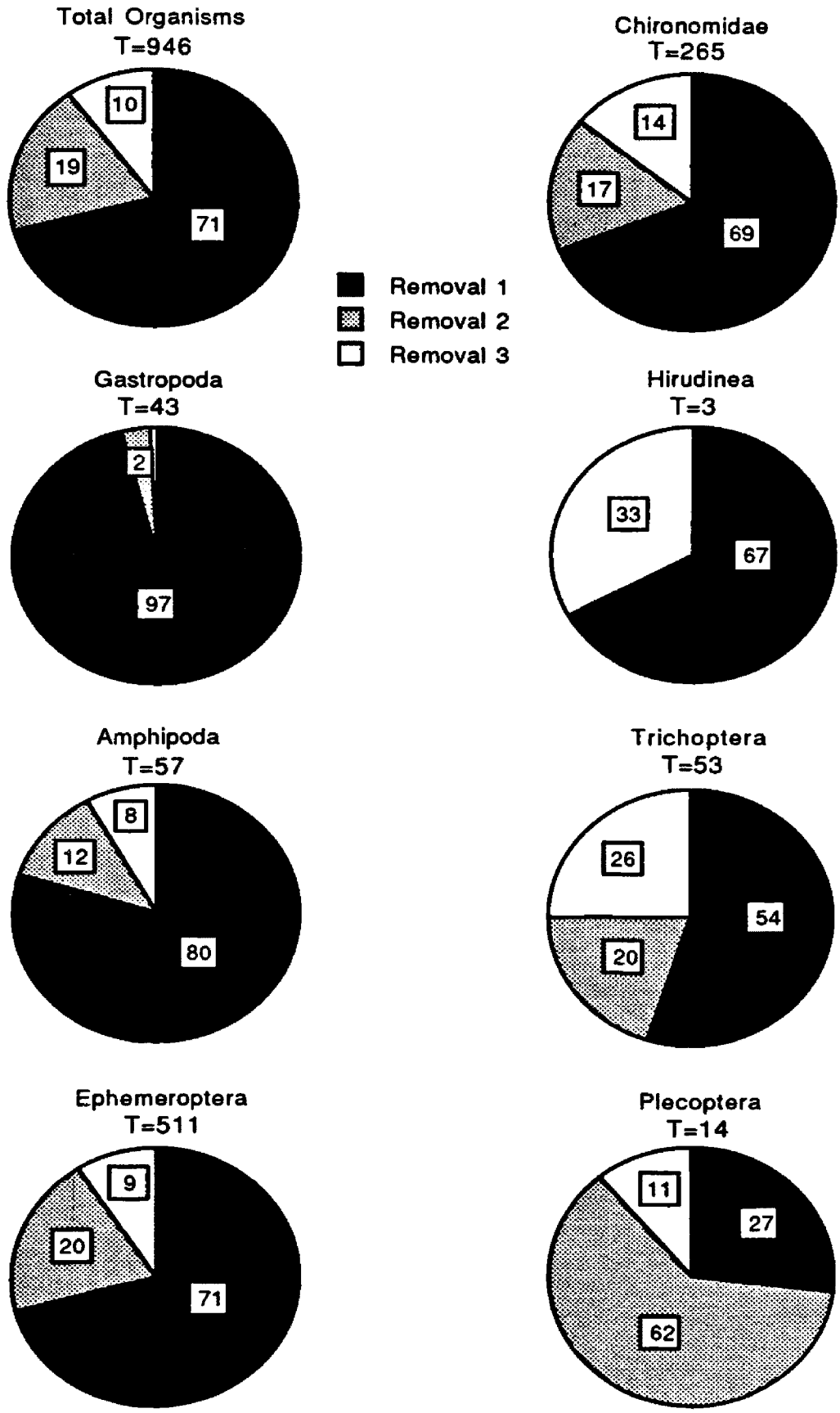

Figure II.3. Mean percentages of major taxonomic groups collected during each of three consecutive removals within a single sampling quadrat ($0.185m^2$). T=total numbers collected for all 9 removals

regressions of total numbers captured against sample number predicted that it would require 5-8 consecutive samples to completely denude a given sample area (Figure II. 4). Thus, the total number of organisms collected during only 3 consecutive removals likely overestimated efficiency.

Gastropoda and Amphipoda were collected most efficiently with 97 ± 3.4% and 80 ± 5.0% of the total numbers collected in the first removal. Efficiency values ranged from 54-71% for Trichoptera, Hirudinea, Chironomidae, and Ephemeroptera. Plecoptera, the least abundant insect taxa, were sampled with the lowest and most variable efficiency of 27 ± 27%.

It was not surprising that Gastropoda and Amphipoda were most efficiently sampled. Gastropoda are relatively nonmotile and easy to capture. Amphipods attempted to avoid the sampler by burrowing directly down into the superficial layers of substratum or in rock crevices, but this escape tactic was ineffective against the sampler's suction power.

Comparison to basket samplers

Taxa representation in the air-lift samples was remarkable in comparison to basket samples. All 32 taxa (genus or family level) represented in basket samples were also found in air-lift samples. Furthermore, an additional six rare genera not found in basket samples were collected with the air-lift sampler. Additionally, the relative abundances of major taxonomic groups were comparable between the two sampling devices for all three sampling zones

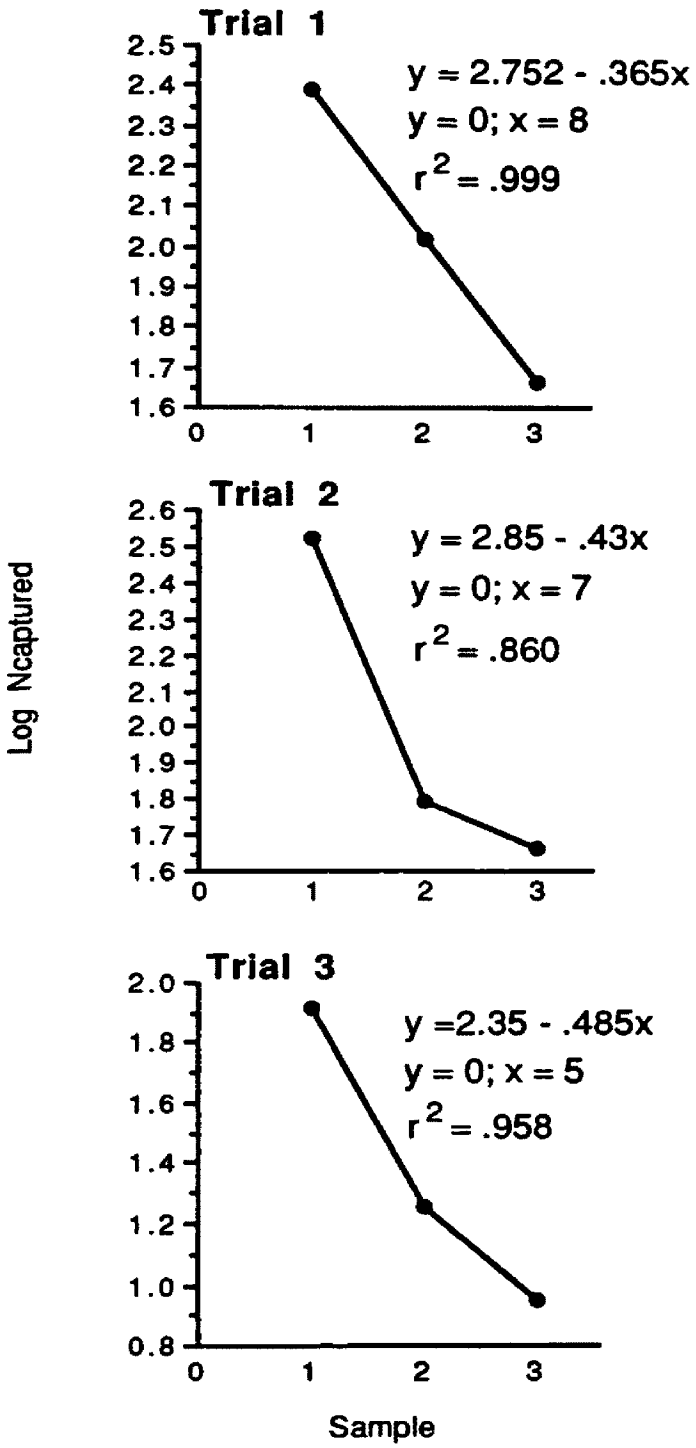

Figure II.4. Logarithm of total macroinvertebrates captured (numbers) during each of three consecutive removals within a single sampling area (0.185m ^{2}) for three trial runs. The predicted number of consecutive samples needed to denude sample area (y = 0) is given for each trial.

(Figure II.5). Chironomidae dominated the communities sampled by both techniques, consisting of 70-95% of total organisms in each of the sampling zones.

Despite the similarities observed among taxonomic compositions of air-lift and basket samples, absolute density estimates of the two samplers were not consistently similar between all three sampling zones. In comparisons within transects, mean abundances of total invertebrates were 2-5 times greater ($P<.05$) in basket samples than air-lift samples for the offshore sloped-bottom zone and the wave zone. In contrast, density estimates of total invertebrates were similar between air-lift and basket samples collected in the offshore flat-bottom zone (Table II.1).

It was possible that the basket samplers attracted higher numbers of organisms than would normally occur on existing substratum in the wave zone and sloped bottom zone. However, it was also likely that the airlift technique underestimated abundance in these two sampling regions. Although the air-lift device worked effectively in these sampling zones, the metal frame used to delineate the sample area ($0.185 m^2$) would often shift with wave action or the removal of substratum along the sloped bottom. This factor caused some interference with sampling time and may have disturbed certain organisms from the delineated sample area.

Suggested improvements

A sampling frame which remains stable along turbulent or

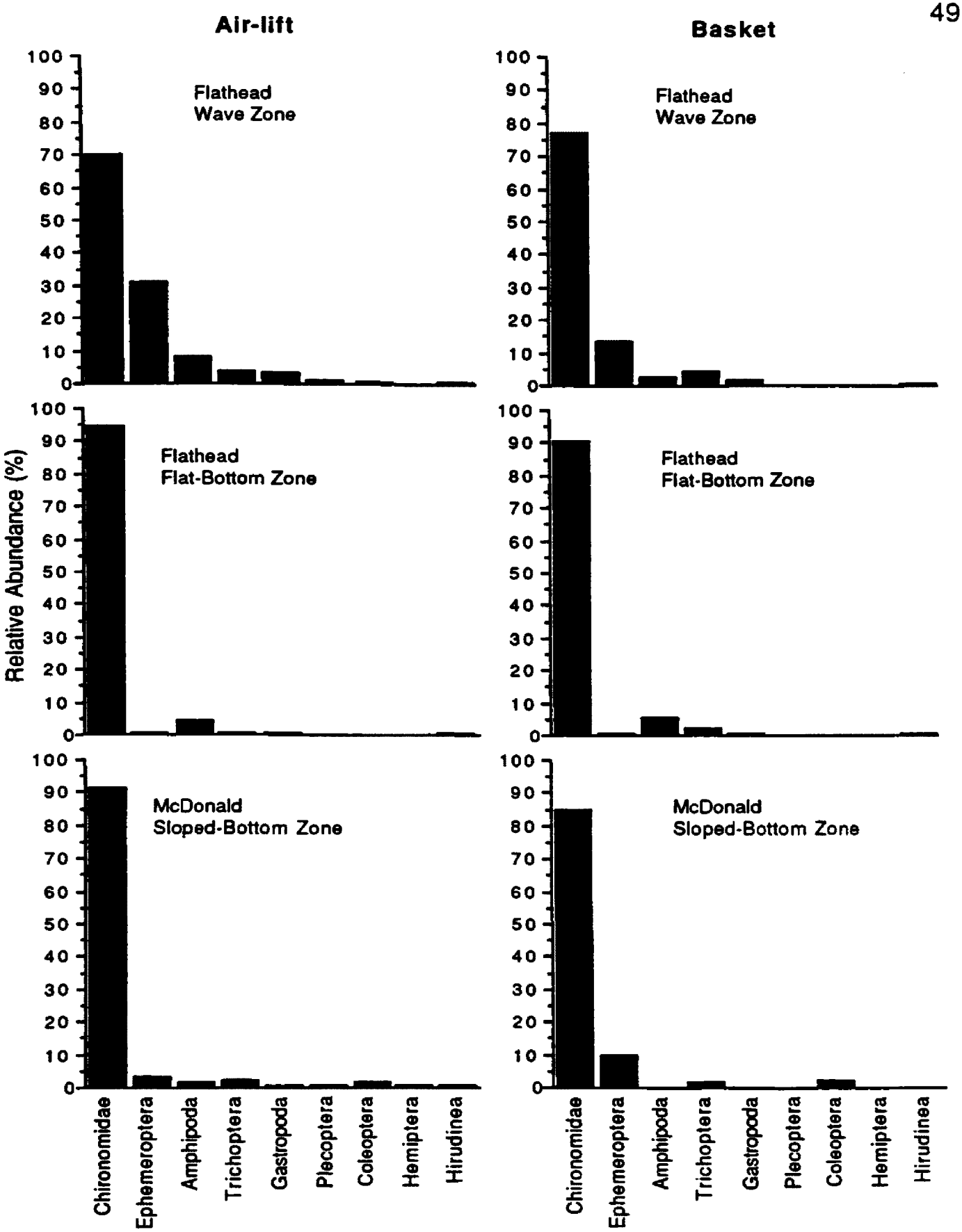

Figure II.5. Mean relative abundance of major taxonomic groups collected with the air-lift and basket samplers in each of the three sampling zones.

Table II.1. Mean abundance (± standard error) of major taxonomic groups collected with the air-lift and basket samplers in the three sampling zones. P-values indicated with (*) are significant at P<.05.

	Flathead 1.5m: wave-zone					4.5m Flathead: flat-bottom zone				
	Site A		Site B			Site A		Site B		
Number of samples	Air-lift (6)	Basket (3)	Air-lift (6)	Basket (3)	ANOVA P-value	Air-lift (6)	Basket (3)	Air-lift (6)	Basket (3)	ANOVA P-value
Chironomidae	2411 (328)	5219 (470)	1388 (315)	7757 (552)	0.0001*	20580 (1547)	18434 (1607)	15241 (1797)	21032 (1602)	0.3507
Ephemeroptera	891 (140)	1315 (338)	140 (4)	943 (107)	0.0014*	12 (3)	68 (31)	52 (8)	136 (29)	0.0003*
Trichoptera	208 (39)	659 (75)	19 (7)	61 (26)	0.0001*	51 (8)	620 (50)	40 (11)	430 (33)	0.0001*
Coleoptera larvae	5 (4)	0	4 (2)	7 (4)	0.9180	0	0	0	0	--------
Coleoptera adults	0	0	0	4 (4)	0.1489	0	0	0	0	--------
Plecoptera	73 (22)	39 (34)	0	0	0.4028	0	4 (4)	0	0	0.1489
Hemiptera	0	0	0	0	-------	0	0	0	0	-------
Amphipoda	331 (60)	326 (168)	135 (29)	111 (28)	0.7980	977 (92)	1369 (133)	669 (37)	932 (63)	0.0021*
Gastropoda	169 (23)	237 (67)	13 (9)	54 (11)	0.0794	125 (40)	72 (9)	55 (20)	180 (36)	0.3305
Hirudinea	24 (9)	75 (6)	2 (1)	18 (13)	0.0008*	25 (13)	172 (22)	1 (1)	22 (6)	0.0001*
Total	4112 (451)	7870 (724)	1701 (308)	8955 (670)	0.0001*	21770 (1599)	20739 (1618)	16058 (1791)	22732 (1752)	0.1643

	McDonald 3.5m: sloped-bottom zone				
	Site A		Site B		
Number of samples	Air-lift (6)	Basket (3)	Air-lift (6)	Basket (2)	ANOVA P-value
Chironomidae	5173 (321)	13747 (317)	5989 (616)	13333 (689)	0.0001*
Ephemeroptera	251 (77)	1285 (91)	124 (21)	1728 (50)	0.0001*
Trichoptera	155 (7)	349 (48)	86 (12)	161 (6)	0.0001*
Coleoptera larvae	74 (17)	145 (38)	87 (24)	236 (110)	0.0378*
Coleoptera adults	14 (7)	81 (27)	37 (13)	229 (50)	0.0001*
Plecoptera	15 (7)	113 (5)	0	0	0.0001*
Hemiptera	4 (4)	108 (65)	14 (6)	7 (4)	0.0650
Amphipoda	90 (15)	5 (5)	144 (98)	100 (36)	0.4530
Gastropoda	62 (19)	97 (65)	37 (15)	64 (35)	0.2805
Hirudinea	4 (3)	81 (48)	2 (2)	97 (27)	0.0001*
Total	5842 (360)	16011 (602)	6520 (731)	15955 (529)	0.0001*

irregular topography is needed to improve the air-lift technique. Perhaps a nylon frame weighted with lead shot around the bottom seam and supported along the sides and top with wire would work more effectively. Additionally, this type of frame would offer more flexible for wedging the weighted bottom edge between rock crevices, thus enclosing the sample area more securely.

The air-lift was very effective at lifting large gravels and small stones into the collection bag along with the organisms. This mixing did cause some damage to the specimens, particularly the fragile mayflies. Therefore, it would be advantageous to add a screen to the suction hose intake. Perhaps a hinged screen would work best so that it could be opened for capturing larger invertebrates, such as crayfish, or for quick unclogging of the screen itself.

SUMMARY AND CONCLUSIONS

1) The air-lift can be assembled in one day and costs less than $100 (USA). 2) The air-lift was effective (efficiency ≈ 71%) for collecting benthic macroinvertebrates from large cobble substratum (>10cm diameter) in shallow littoral zones (1.5-4m depth). 3) Community compositions of air-lift and basket samplers were similar; air-lift samples contained lower densities of total benthos than basket samples. 4) Quantification along turbulent or irregular bottoms may be improved by constructing a better sampling frame. 5) Damage to organisms by the air-lift was minimal, but may be reduced by attaching a screen to the suction hose intake.

Appendix Table I.1. Macroinvertebrates (numbers/m^2) collected with the air-lift sampler (Flathead Lake Varial Zone, August 1991). FN=Flathead Lake North Site; FS=Flathead Lake South Site.

Order	Family	Genus	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-mean	S-mean	Grand Mean	stdev	se
Amphipoda	Gammaridae	Gammarus lacustris	141	157	373	514	324	378	32	65	103	119	22	54	314	88	190	176	124
Amphipoda	Talitridae	Hyalella azteca	5	22	0	22	5	43	65	70	38	151	70	22	18	69	43	38	27
Ephemeroptera	Baetidae	Centroptilum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Caenidae	Caenis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Ephemeridae	Ephemera simulans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Heptagenia	103	97	43	86	49	22	5	5	5	5	0	0	67	4	35	45	32
Ephemeroptera	Heptageniidae	Leucrocuta	0	5	0	11	0	5	0	0	0	0	0	0	4	0	2	3	2
Ephemeroptera	Heptageniidae	Stenonema	92	86	43	43	86	22	0	0	0	0	5	0	62	1	32	43	31
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	551	811	519	492	432	281	114	108	119	124	119	49	514	105	310	289	205
Ephemeroptera	Siphlonuridae	Ameletus	492	314	54	330	173	103	27	11	16	11	27	86	244	30	137	152	107
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	5	0	0	0	16	0	0	0	0	0	0	4	0	2	3	2
Trichoptera	Lepidostomatidae	Lepidostoma	43	114	270	65	65	108	0	0	0	5	0	0	111	1	56	78	55
Trichoptera	Leptoceridae	Ceraclea	86	70	54	27	38	108	0	16	11	16	0	0	64	7	36	40	28
Trichoptera	Leptoceridae	Mystacides	0	11	0	0	0	5	0	0	0	0	0	0	3	0	1	2	1
Trichoptera	Leptoceridae	Oecetis	0	0	0	0	0	22	0	11	0	5	11	11	4	6	5	2	1
Trichoptera	Leptoceridae	Unknown immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus canax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Clistoronia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	11	0	0	0	0	0	0	0	0	0	0	0	2	0	1	1	1
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	0	22	43	22	43	0	0	16	0	5	5	0	22	5	13	12	9
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhynchobdellida	Erpobdellidae	Nephelopsis obscura	38	43	49	0	11	5	0	5	0	0	0	5	24	2	13	16	11
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Lymnaeidae	Stagnicola	162	92	86	103	108	49	0	22	0	0	5	5	98	6	51	64	45
Gastropoda	Physidae	Physella	49	49	81	141	65	22	0	0	0	0	0	0	68	0	34	48	34
Gastropoda	Planorbidae	Gyraulus	5	5	5	0	5	11	0	32	0	0	0	11	5	7	6	1	1
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Planorbidae	Promenetus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Capniidae	Capnia confusa	22	141	97	103	78	0	0	0	0	0	0	0	73	0	36	52	36
Plecoptera	Chloroperlidae	Suwallia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae larvae	0	22	0	5	0	0	0	11	5	0	0	5	5	4	4	1	0
Coleoptera	Dytiscidae	Dytiscidae adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae (Dubiraphia) larva	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae adults	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Ceratopogonidae	Ceratopogonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Chironomidae	2476	3762	2227	2649	2011	1341	2681	1816	1438	773	995	627	2411	1388	1900	723	511
Total Organisms	Total Organisms	Total Organisms	4278	5827	3924	4811	3492	2541	2924	2189	1735	1216	1259	876	4112	1700	2906	1705	1206

Appendix Table I.2. Macroinvertebrates (numbers/m^2) collected with the air-lift sampler (Flathead Lake Varial Zone, October 1991). FN=Flathead Lake North Site; FS=Flathead Lake South Site.

Order	Family	Genus	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-mean	S-mean	Grand Mean	stdev	se
Amphipoda	Gammaridae	Gammarus lacustris	81	16	49	no count	103	70	54	38	32	27	no count	32	64	37	50	19	14
Amphipoda	Talitridae	Hyalella azteca	16	22	54	no count	16	22	0	38	6	5	no count	16	26	13	19	9	6
Ephemeroptera	Baetidae	Centroptilum	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Ephemeroptera	Caenidae	Caenis	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Ephemeroptera	Ephemeridae	Ephemera simulans	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Heptagenia	97	16	135	no count	43	114	65	16	59	103	no count	43	81	57	69	17	12
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	216	135	178	no count	222	189	162	124	124	168	no count	38	188	123	156	46	32
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	724	92	1016	no count	324	770	65	178	22	70	no count	32	586	74	330	362	256
Ephemeroptera	Siphlonuridae	Ameletus	16	38	32	no count	49	49	0	0	16	5	no count	0	37	4	21	23	16
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	5	0	no count	0	0	0	11	5	0	no count	5	1	4	3	2	2
Trichoptera	Lepidostomatidae	Lepidostoma	0	59	0	no count	22	5	0	0	0	0	no count	0	17	0	9	12	9
Trichoptera	Leptoceridae	Ceraclea	16	5	0	no count	0	16	0	0	0	0	no count	0	8	0	4	5	4
Trichoptera	Leptoceridae	Mystacides	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Leptoceridae	Oecetis	49	22	81	no count	54	64	11	11	0	5	no count	5	52	8	29	32	23
Trichoptera	Leptoceridae	Unknown immature	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus canax	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Limnephilidae	Clistoronia	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	0	5	0	no count	0	0	0	0	0	5	no count	0	1	1	1	0	0
Trichoptera	Polycentropodidae	Nyctophylax	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Pharyngobdellida	Erpobdellidae	Nephelopsis obscura	5	49	0	no count	0	5	5	0	5	0	no count	0	12	2	7	7	5
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Gastropoda	Lymnaeidae	Stagnicola	59	27	81	no count	119	59	0	5	5	11	no count	16	59	8	38	44	31
Gastropoda	Physidae	Physella	0	0	5	no count	0	0	5	16	0	11	no count	11	1	9	5	5	4
Gastropoda	Planorbidae	Gyraulus	5	0	16	no count	11	11	54	0	0	108	no count	38	9	40	24	22	16
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Gastropoda	Planorbidae	Promenetus	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Plecoptera	Capniidae	Capnia confusa	38	0	59	no count	0	43	0	0	0	0	no count	0	28	0	14	20	14
Plecoptera	Chloroperlidae	Suwallia	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae larvae	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae adult	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae (Dubiraphia) larv	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae adults	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Hemiptera	Corixidae	Corixidae	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Odonata	Gomphidae	Ophiogomphus	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Diptera	Ceratopogonidae	Ceratopogonidae	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0
Diptera	Chironomidae	Chironomidae	216	843	319	no count	368	373	205	924	195	205	no count	530	424	412	418	8	6
Total Organisms	Total Organisms	Total Organisms	1541	1335	2027	no count	1330	1784	627	1362	470	724	no count	768	1603	780	1107	575	406

Appendix Table I.3. Macroinvertebrates (numbers/m^2) collected with the air-lift sampler (Flathead Lake Permanently Wetted Zone, May 1991). FN=Flathead Lake North Site; FS=Flathead Lake South Site.

Order	Family	Genus	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-mean	S-mean	Grand Mean	stdev	se
Amphipoda	Gammaridae	Gammarus lacustris	0	0	0	0	0	0	0	0	0	11	0	0	0	2	1	1	1
Amphipoda	Talitridae	Hyalella azteca	768	719	973	703	595	346	243	389	146	384	243	703	684	351	518	235	166
Ephemeroptera	Baetidae	Centroptilum	0	0	0	0	0	5	0	0	0	22	0	5	1	5	3	3	2
Ephemeroptera	Caenidae	Caenis	0	5	5	11	0	0	11	11	0	0	16	5	4	7	5	3	2
Ephemeroptera	Ephemeridae	Ephemera simulans	16	88	11	22	11	38	22	65	5	32	22	32	31	30	30	1	0
Ephemeroptera	Heptageniidae	Heptagenia	16	0	11	11	27	16	5	0	0	5	0	0	14	2	8	8	6
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	38	54	65	5	70	27	38	5	0	5	5	11	43	11	27	23	16
Ephemeroptera	Leptophlebiidae	Leptophlebia	38	38	59	81	27	5	5	0	0	0	0	0	41	1	21	29	20
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	Ameletus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	22	49	0	0	0	0	5	59	22	59	43	0	12	32	22	14	10
Trichoptera	Lepidostomatidae	Lepidostoma	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	1	0
Trichoptera	Leptoceridae	Ceraclea	38	32	5	5	32	11	0	0	0	0	0	0	21	0	10	16	10
Trichoptera	Leptoceridae	Mystacides	5	0	16	5	11	16	0	0	0	0	49	11	9	10	9	1	0
Trichoptera	Leptoceridae	Oecetis	11	5	11	11	27	27	22	11	5	0	0	0	15	6	11	8	6
Trichoptera	Leptoceridae	Unknown immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus canax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	11	32	16	5	22	11	5	5	5	11	0	0	16	5	10	8	6
Trichoptera	Limnephilidae	Clistoronia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	5	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Trichoptera	Polycentropodidae	Polycentropus	38	27	38	11	27	16	16	38	5	11	11	11	25	15	20	7	5
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0	0	0	16	0	11	0	5	0	5	3	4	3
Pharyngobdellida	Erpobdellidae	Nephelopsis obscura	0	0	0	5	0	5	0	0	0	0	0	0	2	0	1	1	1
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	0	5	0	32	0	0	0	0	0	0	6	0	3	4	3
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Lymnaeidae	Stagnicola	27	16	0	27	32	0	11	43	11	27	22	76	17	32	24	10	7
Gastropoda	Physidae	Physella	5	5	0	0	43	0	0	0	0	0	0	0	9	0	5	8	5
Gastropoda	Planorbidae	Gyraulus	0	5	0	0	11	5	0	11	5	0	5	43	4	11	7	8	4
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Planorbidae	Promenetus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	5	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Pisciopiora	Cyprinidae	Cyprinus carpio	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Chloroperlidae	Suwallia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae (Dubiraphia) larv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae adults	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Ceratopogonidae	Ceratopogonidae	0	43	0	5	0	0	0	0	0	0	0	0	8	0	4	8	4
Diptera	Chironomidae	Chironomidae	11854	10373	9173	10281	9000	6454	7348	12195	6135	6822	6016	11800	9523	6388	8954	804	568
Total Organisms	Total Organisms	Total Organisms	12886	11497	10389	11195	9930	7022	7730	12849	6340	7400	6432	12703	10486	6909	9698	1115	789

Appendix Table I.4. Macroinvertebrates (numbers/m^2) collected with the air-lift sampler (Flathead Lake Permanently Wetted Zone, August 1991). FN=Flathead Lake North Site; FS=Flathead Lake South Site.

Order	Family	Genus	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-mean	S-mean	Grand Mean	stdev	se
Amphipoda	Gammaridae	Gammarus lacustris	212	259	49	92	195	70	92	70	135	43	54	54	150	75	112	53	37
Amphipoda	Talitridae	Hyalella azteca	984	941	816	865	816	541	632	470	578	649	519	714	827	594	710	165	117
Ephemeroptera	Baetidae	Centroptilum	0	5	0	5	0	0	5	0	0	0	0	0	2	1	1	1	0
Ephemeroptera	Caenidae	Caenis	0	0	5	5	0	0	22	27	38	27	16	16	2	24	13	16	11
Ephemeroptera	Ephemeridae	Ephemera simulans	0	0	0	0	0	0	27	0	0	0	0	0	0	5	2	3	2
Ephemeroptera	Heptageniidae	Heptagenia	11	0	0	0	0	0	0	0	0	0	5	0	2	1	1	1	0
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	5	5	0	5	16	0	0	0	0	0	0	0	5	0	3	4	3
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	0	0	0	5	0	0	11	22	32	38	16	5	1	21	11	14	10
Ephemeroptera	Siphlonuridae	Ameletus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	5	0	0	0	0	0	0	0	0	5	0	0	1	1	1	0	0
Trichoptera	Lepidostomatidae	Lepidostoma	0	0	0	0	0	5	0	5	0	0	0	0	1	1	1	0	0
Trichoptera	Leptoceridae	Ceraclea	32	11	11	22	22	22	11	0	5	5	0	11	20	5	13	10	7
Trichoptera	Leptoceridae	Mystacides	0	5	0	11	0	0	5	0	0	0	0	0	3	1	2	1	1
Trichoptera	Leptoceridae	Oecetis	11	0	5	22	16	16	22	54	16	11	5	5	12	19	15	5	4
Trichoptera	Leptoceridae	Unknown immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus canax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	16	0	0	16	11	22	5	5	0	5	0	0	11	3	7	8	4
Trichoptera	Limnephilidae	Clistoronia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	5	11	0	0	0	0	0	0	0	0	0	3	0	1	2	1
Trichoptera	Polycentropodidae	Polycentropus	5	5	0	0	0	0	0	5	0	0	0	0	2	1	1	1	0
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0	0	11	16	5	5	5	11	0	6	5	6	5
Rhynchobdellida	Erpobdellidae	Nephelopsis obscura	0	11	5	0	0	38	0	0	0	0	5	0	9	1	5	6	4
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	5	76	0	0	0	0	0	0	0	0	14	0	7	10	7
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	5	5	5	0	0	0	0	0	0	0	0	3	0	1	2	1
Gastropoda	Lymnaeidae	Stagnicola	32	49	146	259	43	43	27	119	0	22	5	27	95	33	64	44	31
Gastropoda	Physidae	Physella	0	11	0	11	0	0	0	0	0	0	0	0	4	0	2	3	2
Gastropoda	Planorbidae	Gyraulus	22	27	0	0	0	0	27	27	5	22	22	22	7	21	14	10	7
Gastropoda	Planorbidae	Helisoma anceps anceps	0	32	43	5	5	0	0	0	0	5	0	0	14	1	8	10	7
Gastropoda	Planorbidae	Promenetus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	0	27	0	0	0	0	0	0	0	0	0	5	0	2	3	2
Plecoptera	Capniidae	Capnia confusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Chloroperlidae	Suwallia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae (Dubiraphia) larv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae adults	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Ceratopogonidae	Ceratopogonidae	0	5	5	0	5	0	5	5	5	43	11	0	3	12	7	6	5
Diptera	Chironomidae	Chironomidae	22519	23054	16535	26136	16800	20638	16151	13892	21443	9941	16924	11092	20880	16241	17910	3776	2670
Total Organisms	Total Organisms	Total Organisms	23878	24427	17670	26541	16730	21395	16054	14719	22265	10822	17589	11957	21773	16068	18920	4034	2853

Appendix Table I.5. Macroinvertebrates (numbers/m^2) collected with the air-lift sampler (Flathead Lake Permanently Wetted Zone, October 1991). FN=Flathead Lake North Site; FS=Flathead Lake South Site.

Order	Family	Genus	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-mean	S-mean	Grand Mean	stdev	se
Amphipods	Gammaridae	Gammarus lacustris	5	27	5	32	11	27	54	32	22	11	5	65	18	32	25	10	7
Amphipods	Talitridae	Hyalella azteca	357	551	422	486	800	611	622	670	535	411	400	584	538	537	537	1	0
Ephemeroptera	Baetidae	Centroptilum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Caenidae	Caenis	5	0	11	0	0	0	200	130	65	76	114	168	3	125	64	67	61
Ephemeroptera	Ephemeridae	Ephemera simulans	11	22	11	16	0	22	59	22	5	11	22	11	14	22	18	6	4
Ephemeroptera	Heptageniidae	Heptagenia	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	1	0
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	32	22	5	22	11	5	0	0	0	0	5	0	16	1	9	11	8
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	11	54	16	22	32	11	0	11	0	5	0	5	24	4	14	15	10
Ephemeroptera	Siphlonuridae	Ameletus	0	0	0	0	0	11	0	0	0	0	0	0	2	0	1	1	1
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	32	11	5	5	0	22	22	97	11	27	32	16	13	34	23	15	11
Trichoptera	Lepidostomatidae	Lepidostoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Leptoceridae	Ceraclea	22	65	16	22	16	11	5	0	11	5	0	0	25	4	14	15	11
Trichoptera	Leptoceridae	Mystacides	0	0	0	0	0	0	0	0	0	0	0	5	0	1	0	1	0
Trichoptera	Leptoceridae	Oecetis	0	22	0	5	0	16	22	22	0	0	0	11	7	9	8	1	1
Trichoptera	Leptoceridae	Unknown immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus canax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	0	54	0	0	5	0	0	0	0	0	0	10	0	5	7	5
Trichoptera	Limnephilidae	Clistoronia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	49	38	38	70	49	43	32	43	49	16	43	27	48	35	41	9	6
Trichoptera	Polycentropodidae	Nyctiophylax	0	5	0	0	5	0	22	11	22	32	59	27	2	29	15	19	14
Pharyngobdellida	Erpobdellidae	Nephelopsis obscura	5	5	0	11	0	0	0	0	0	0	0	0	4	0	2	3	2
Rhynchobdellida	Glossiphonidae	Helobdella stagnalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhynchobdellida	Glossiphonidae	Glossiphonia complanata	5	0	0	5	0	0	0	0	0	0	0	0	2	0	1	1	1
Gastropoda	Lymnaeidae	Stagnicola	5	5	5	11	38	5	22	108	81	16	86	22	12	56	34	31	22
Gastropoda	Physidae	Physella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Planorbidae	Gyraulus	32	43	76	60	38	81	16	32	43	38	16	16	65	27	41	20	14
Gastropoda	Planorbidae	Helisoma anceps anceps	5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Gastropoda	Planorbidae	Promenetus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Capniidae	Capnia confusa	0	11	0	0	0	0	0	0	0	0	0	0	2	0	1	1	1
Plecoptera	Chloroperlidae	Suwallia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae adult	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae (Dubiraphia) larva	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	Elmidae adults	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Ceratopogonidae	Ceratopogonidae	0	11	5	0	0	0	0	0	0	0	0	0	3	0	1	2	1
Diptera	Chironomidae	Chironomidae	10108	9811	11119	10805	13032	8292	7724	8941	7822	7018	5881	9724	10495	7851	9173	1869	1322
Total Organisms	Total Organisms	Total Organisms	10686.5	10703	11789	11373	14032	9182	8805	10119	8665	7665	6665	10681	11291	8787	10029	1785	1262

Appendix Table I.6. Macroinvertebrates (numbers/m^2) collected with the air-lift sampler (Lake McDonald Varial Zone, August 1991). MN=Lake McDonald North Site; MS=Lake McDonald South Site.

Order	Family	Genus	MN-A-1	MN-A-2	MN-A-3	MN-A-4	MN-A-5	MN-A-6	MS-A-1	MS-A-2	MS-A-3	MS-A-4	MS-A-5	MS-A-6	N-mean	S-mean	Grand Mean	stdev	se
Amphipoda	Gammaridae	Gammarus lacustris	164	211	97	38	110	70	114	32	32	43	135	135	122	82	102	28	20
Amphipoda	Talitridae	Hyalella azteca	178	218	108	427	418	454	211	173	49	27	32	43	304	89	196	152	107
Ephemeroptera	Baetidae	Centroptilum	11	16	32	5	16	27	0	16	5	16	0	22	18	10	14	6	4
Ephemeroptera	Caenidae	Caenis	16	11	16	11	5	22	11	0	0	11	11	5	14	6	10	5	4
Ephemeroptera	Ephemeridae	Ephemera simulans	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	1	0
Ephemeroptera	Heptageniidae	Heptagenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Leucrocuta	16	11	16	22	43	22	22	16	22	11	11	22	22	17	19	3	2
Ephemeroptera	Heptageniidae	Stenonema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	227	265	519	222	514	303	232	210	76	141	281	178	341	187	264	109	77
Ephemeroptera	Siphlonuridae	Ameletus	0	0	0	0	0	0	32	22	76	54	59	54	0	50	25	35	25
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Lepidostomatidae	Lepidostoma	108	119	97	92	162	81	11	5	5	22	11	16	110	12	61	69	49
Trichoptera	Leptoceridae	Ceraclea	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0	1	0
Trichoptera	Leptoceridae	Mystacides	11	22	5	0	5	16	5	5	5	5	11	5	10	6	8	3	2
Trichoptera	Leptoceridae	Oecetis	0	0	0	0	0	0	0	0	0	0	43	0	0	7	4	5	4
Trichoptera	Leptoceridae	Unknown immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus canax	0	0	0	0	0	0	0	0	0	5	0	0	0	1	0	1	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	5	5	5	27	11	0	11	0	16	0	16	9	7	8	1	1
Trichoptera	Limnephilidae	Chiloteria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pharyngobdellida	Erpobdellidae	Nephelopsis obscura	27	0	27	22	5	11	5	0	0	0	22	11	15	6	11	8	5
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	0	5	0	0	5	0	0	0	0	0	0	2	0	1	1	1
Gastropoda	Lymnaeidae	Stagnicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Physidae	Physella	195	86	32	108	59	195	32	16	11	65	86	81	113	49	81	45	32
Gastropoda	Planorbidae	Gyraulus	0	0	0	0	5	0	0	0	0	0	0	0	1	0	0	1	0
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Planorbidae	Promenetus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Capniidae	Capnia confusa	49	249	238	368	368	324	184	151	27	11	173	124	268	112	189	109	77
Plecoptera	Chloroperlidae	Sweltsa	5	0	0	5	16	49	0	0	0	0	5	5	13	2	7	8	5
Coleoptera	Dytiscidae	Dytiscidae larvae	87	11	11	32	32	11	11	5	0	11	0	11	32	6	19	18	13
Coleoptera	Dytiscidae	Dytiscidae adult	27	5	0	0	0	0	0	5	5	0	5	5	5	4	5	1	1
Coleoptera	Elmidae	Elmidae (Dubiraphia) larva	0	0	0	0	0	0	0	5	0	22	0	43	0	12	8	8	6
Coleoptera	Elmidae	Elmidae adults	5	0	0	5	0	0	0	0	0	0	0	0	2	0	1	1	1
Hemiptera	Corixidae	Corixidae	0	5	0	0	0	0	0	5	0	11	5	0	1	4	2	2	1
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0	0	5	0	0	5	0	0	2	1	1	1
Diptera	Ceratopogonidae	Ceratopogonidae	0	0	0	0	0	0	22	0	0	5	5	43	0	13	8	9	6
Diptera	Chironomidae	Chironomidae	2146	2314	1070	1968	2373	1465	1878	1768	2027	1481	1811	1005	1989	1661	1775	181	114
Total Organisms	Total Organisms	Total Organisms	3303	3548	2281	3330	4200	3070	2768	2459	2341	1957	2719	1827	3288	2345	2817	667	472

Appendix Table I.7. Macroinvertebrates (numbers/m^2) collected with the air-lift sampler (Lake McDonald Permanently Wetted Zone, May 1991). MN=Lake McDonald North Site; MS=Lake McDonald South Site.

Order	Family	Genus	MN-S-1	MN-S-2	MN-S-3	MN-S-4	MN-S-5	MN-S-6	MS-S-1	MS-S-2	MS-S-3	MS-S-4	MS-S-5	MS-S-6	N-mean	S-mean	Grand Mean	stdev	se
Amphipoda	Gammaridae	Gammarus lacustris	0	5	0	0	no count	0	0	0	0	0	0	0	1	0	1	1	1
Amphipoda	Talitridae	Hyalella azteca	54	22	27	11	no count	22	5	16	22	5	38	11	27	16	22	8	5
Ephemeroptera	Baetidae	Centroptilum	0	0	0	0	no count	0	0	5	0	0	0	0	0	1	0	1	0
Ephemeroptera	Caenidae	Caenis	27	27	5	0	no count	5	0	0	0	0	5	0	13	1	7	9	6
Ephemeroptera	Ephemeridae	Ephemera simulans	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Heptagenia	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Leucrocuta	86	81	0	5	no count	38	0	22	5	11	0	16	42	9	26	23	17
Ephemeroptera	Heptageniidae	Stenonema	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Leptophlebia	92	22	16	54	no count	81	22	5	27	11	0	0	53	11	32	30	21
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	Ameletus	0	0	0	0	no count	0	0	0	5	0	5	0	0	2	1	1	1
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	0	0	0	no count	0	11	22	27	32	22	0	0	19	9	13	9
Trichoptera	Lepidostomatidae	Lepidostoma	54	5	38	0	no count	49	22	0	0	0	27	11	29	10	20	14	10
Trichoptera	Leptoceridae	Ceraclea	11	5	0	0	no count	0	0	0	0	0	0	0	3	0	2	2	2
Trichoptera	Leptoceridae	Mystacides	11	27	0	32	no count	11	16	0	0	0	0	5	16	4	10	9	6
Trichoptera	Leptoceridae	Oecetis	5	5	0	22	no count	0	0	0	5	0	0	0	6	1	4	4	3
Trichoptera	Leptoceridae	Unknown immature	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus canax	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	16	22	11	0	no count	11	5	0	5	0	5	0	12	3	7	8	5
Trichoptera	Limnephilidae	Clistoronia	5	0	0	0	no count	0	0	0	0	0	5	0	1	1	1	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	22	16	0	0	no count	5	32	5	11	0	5	11	9	11	10	2	1
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	no count	0	11	11	5	0	5	0	0	5	3	4	3
Rhynchobdellida	Erpobdellidae	Nephelopsis obscura	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Lymnaeidae	Stagnicola	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Physidae	Physella	11	5	0	0	no count	0	0	0	5	0	0	0	3	1	2	2	1
Gastropoda	Planorbidae	Gyraulus	38	81	43	38	no count	22	5	32	5	16	16	5	44	14	29	22	15
Gastropoda	Planorbidae	Helisoma sharpi group	0	5	0	0	no count	5	0	0	0	0	0	0	2	0	1	2	1
Gastropoda	Planorbidae	Promenetus	11	0	0	0	no count	0	0	0	0	0	0	0	2	0	1	2	1
Gastropoda	Valvatidae	Valvata humeralis	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Capniidae	Capnia confusa	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Chloroperlidae	Sweltsa	5	0	0	0	no count	5	0	0	0	0	0	0	2	0	1	2	1
Coleoptera	Dytiscidae	Dytiscidae larvae	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae adult	16	11	0	5	no count	0	0	0	0	0	0	0	9	0	3	5	3
Coleoptera	Elmidae	Elmidae (Dubiraphia) larva	0	5	0	0	no count	0	38	5	0	0	27	0	1	12	8	8	5
Coleoptera	Elmidae	Elmidae adults	0	0	0	0	no count	0	0	0	16	0	0	0	0	3	1	2	1
Hemiptera	Corixidae	Corixidae	0	22	5	5	no count	0	0	0	0	0	0	5	0	1	4	4	3
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	no count	0	0	0	0	0	0	0	0	1	0	1	0
Diptera	Ceratopogonidae	Ceratopogonidae	0	0	0	0	no count	0	0	0	0	0	0	0	1	0	1	1	1
Diptera	Chironomidae	Chironomidae	8562	5932	2535	3078	no count	3427	7335	7178	8638	4611	9188	4692	4888	6937	5812	1591	1125
Total Organisms	Total Organisms	Total Organisms	9027	6200	2681	3249	no count	3666	7503	7303	8778	4686	9335	4757	4969	7060	6015	1479	1046

Appendix Table I.8. Macroinvertebrates (numbers/m^2) collected with the air-lift sampler (Lake McDonald Permanently Wetted Zone, August 1991). MN=Lake McDonald North Site; MS=Lake McDonald South Site.

Order	Family	Genus	MN-B-1	MN-B-2	MN-B-3	MN-B-4	MN-B-5	MN-B-6	MS-B-1	MS-B-2	MS-B-3	MS-B-4	MS-B-5	MS-B-6	N-mean	S-mean	Grand Mean	stdev	se
Amphipoda	Gammaridae	Gammarus lacustris	22	27	32	5	27	49	5	22	5	5	0	5	27	7	17	14	10
Amphipoda	Talitridae	Hyalella azteca	81	5	70	54	92	76	27	38	0	827	76	54	63	137	100	52	37
Ephemeroptera	Baetidae	Centroptilum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Caenidae	Caenis	11	11	0	16	114	0	27	0	5	11	11	0	25	9	17	11	8
Ephemeroptera	Ephemeridae	Ephemera simulans	0	0	0	0	0	0	0	0	0	0	5	0	0	1	0	1	0
Ephemeroptera	Heptageniidae	Heptagenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Leucrocuta	0	5	0	0	11	0	5	5	11	5	0	5	3	5	4	2	1
Ephemeroptera	Heptageniidae	Stenonema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	278	265	76	103	470	151	103	114	11	108	135	162	223	105	164	83	58
Ephemeroptera	Siphlonuridae	Ameletus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0	0	0	0	11	0	11	0	4	2	3	2
Trichoptera	Hydroptilidae	Hydroptila	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Lepidostomatidae	Lepidostoma	49	16	59	27	32	54	22	11	43	16	32	5	40	22	31	13	9
Trichoptera	Leptoceridae	Ceraclea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Leptoceridae	Mystacides	11	27	38	32	32	5	16	16	11	27	16	22	24	18	21	4	3
Trichoptera	Leptoceridae	Oecetis	0	0	0	0	0	0	0	0	0	27	38	0	0	11	5	8	5
Trichoptera	Leptoceridae	Unknown immature	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus canax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
Trichoptera	Limnephilidae	Apatania	65	59	49	16	65	27	5	5	5	16	11	5	47	8	27	27	19
Trichoptera	Limnephilidae	Chilostigma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	38	49	11	49	49	65	27	49	0	11	16	22	43	21	32	16	11
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0	0	0	0	0	11	22	11	0	7	4	5	4
Pharyngodelfida	Erpobdellidae	Nephelopsis obscura	0	5	5	16	0	0	0	0	0	0	11	0	5	2	3	2	1
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Lymnaeidae	Stagnicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Physidae	Physella	5	5	0	5	0	43	32	5	0	87	0	0	10	23	16	8	6
Gastropoda	Planorbidae	Gyraulus	86	5	5	108	16	5	0	32	22	11	0	11	38	13	25	18	13
Gastropoda	Planorbidae	Helisoma anceps anceps	0	5	5	0	0	0	0	0	0	0	0	0	2	0	1	1	1
Gastropoda	Planorbidae	Promenetus	11	0	27	11	0	11	0	5	0	0	0	0	10	1	5	8	5
Gastropoda	Valvatidae	Valvata humeralis	11	0	0	0	0	5	0	0	0	0	0	5	3	1	2	1	1
Plecoptera	Capniidae	Capnia confusa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	Chloroperlidae	Sweltsa	11	11	0	5	49	11	0	0	0	0	0	0	14	0	7	10	7
Coleoptera	Dytiscidae	Dytiscidae larvae	16	11	5	0	0	16	0	22	0	11	5	5	8	7	8	1	0
Coleoptera	Dytiscidae	Dytiscidae adult	5	0	0	5	0	5	0	0	0	5	0	11	3	3	3	0	0
Coleoptera	Elmidae	Elmidae (Dubiraphia) larvae	11	103	92	43	119	27	146	86	0	16	114	114	86	79	73	10	7
Coleoptera	Elmidae	Elmidae adults	0	27	0	0	43	0	11	16	0	49	65	65	12	34	23	16	11
Hemiptera	Corixidae	Corixidae	22	0	0	0	0	0	43	5	0	16	16	5	4	14	9	8	5
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Ceratopogonidae	Ceratopogonidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Chironomidae	Chironomidae	4335	5973	4714	4378	5832	6005	6935	5095	3454	7973	5859	5919	5173	5989	5581	577	408
Total Organisms	Total Organisms	Total Organisms	5070	6611	5189	4876	6751	6557	7405	6427	3568	9054	6232	6438	5842	6521	6182	480	339

Appendix Table I.9. Macroinvertebrates (numbers/m^2) collected with the air-lift sampler (Lake McDonald Permanently Wetted Zone, October 1991). MN=Lake McDonald North Site; MS=Lake McDonald South Site.

Order	Family	Genus	MN-B-1	MN-B-2	MN-B-3	MN-B-4	MN-B-5	MN-B-6	MS-B-1	MS-B-2	MS-B-3	MS-B-4	MS-B-5	MS-B-6	N-mean	S-mean	Grand Mean	stdev	se
Amphipoda	Gammaridae	Gammarus lacustris	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphipoda	Talitridae	Hyalella azteca	54	49	22	11	97	0	11	0	0	0	16	22	39	8	23	22	15
Ephemeroptera	Baetidae	Centroptilum	0	5	0	5	0	0	0	0	0	0	0	0	2	0	1	1	1
Ephemeroptera	Caenidae	Caenis	151	157	59	76	151	38	0	27	5	5	114	66	105	40	73	47	33
Ephemeroptera	Ephemeridae	Ephemera simulans	0	0	0	0	11	0	254	0	0	0	92	0	2	58	30	39	28
Ephemeroptera	Heptageniidae	Heptagenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Leucrocuta	27	130	11	114	11	27	0	0	0	43	5	0	53	8	31	32	23
Ephemeroptera	Heptageniidae	Stenonema	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	135	216	97	130	103	43	16	130	27	292	238	76	121	130	125	8	5
Ephemeroptera	Siphlonuridae	Ameletus	22	92	81	54	11	54	11	27	11	11	11	27	52	16	34	25	18
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	0	0	0	0	0	486	76	43	92	43	49	0	132	66	93	66
Trichoptera	Lepidostomatidae	Lepidostoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Leptoceridae	Ceraclea	0	0	0	5	5	5	0	0	0	0	0	0	3	0	1	2	1
Trichoptera	Leptoceridae	Mystacides	5	5	0	0	0	0	0	0	0	0	5	0	2	1	1	1	0
Trichoptera	Leptoceridae	Oecetis	11	22	11	11	11	22	5	5	22	11	32	27	14	17	16	2	1
Trichoptera	Leptoceridae	Unknown immature	27	184	43	86	97	11	0	0	0	0	0	0	75	0	37	53	37
Trichoptera	Limnephilidae	Amphicosmoecus canax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	5	0	0	0	0	0	0	0	5	0	0	1	1	1	0	0
Trichoptera	Limnephilidae	Clostoeria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	5	16	16	11	11	5	5	27	27	5	54	0	11	20	15	8	5
Trichoptera	Molannidae	Molanna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	16	22	0	43	32	16	32	27	32	22	65	32	22	35	28	10	7
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0	0	0	22	0	0	5	5	0	5	3	4	3
Rhynchobdellida	Erpobdellidae	Nephelopsis obscura	0	0	0	0	0	0	0	5	0	0	16	11	0	5	3	4	3
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	5	0	0	0	5	0	0	0	0	0	5	5	2	2	2	0	0
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	0	5	11	0	0	5	0	0	0	5	0	3	2	2	1	0
Gastropoda	Lymnaeidae	Stagnicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Physidae	Physella	0	0	5	0	0	5	5	5	5	11	16	43	2	14	8	8	6
Gastropoda	Planorbidae	Gyraulus	27	38	86	135	43	65	178	70	16	70	0	178	66	86	76	14	10
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Planorbidae	Promenetus	27	108	65	11	16	5	0	0	0	5	5	0	39	2	20	29	19
Gastropoda	Valvatidae	Valvata humeralis	0	0	0	0	0	0	5	5	0	0	0	5	0	3	1	2	1
Plecoptera	Capniidae	Capnia confusa	16	81	5	43	5	0	0	0	0	43	43	0	25	14	20	8	5
Plecoptera	Chloroperlidae	Sweltsa	11	0	0	0	11	0	0	0	0	0	0	0	4	0	2	3	2
Coleoptera	Dytiscidae	Dytiscidae larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	Dytiscidae adult	0	11	5	0	0	0	0	5	0	0	11	0	3	3	3	0	0
Coleoptera	Elmidae	Elmidae (Dubiraphia) larvae	65	103	16	49	86	0	227	5	5	227	611	270	53	225	139	122	86
Coleoptera	Elmidae	Elmidae adults	16	22	5	0	32	11	5	5	38	59	43	65	14	36	25	15	11
Hemiptera	Corixidae	Corixidae	65	32	11	0	0	5	0	0	0	0	0	0	19	0	9	13	9
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0	5	0	5	0	0	5	0	3	1	2	1
Diptera	Ceratopogonidae	Ceratopogonidae	0	0	0	0	0	0	11	5	0	0	16	0	0	5	3	4	3
Diptera	Chironomidae	Chironomidae	2470	2254	3638	1568	3897	2957	10735	7881	3573	6076	11211	8568	2764	8007	5386	3709	2622
Total Organisms	Total Organisms	Total Organisms	3157	3551	4184	2382	4439	3270	12000	8330	3811	6978	12665	9481	3494	8877	6186	3907	2892

Appendix Table II.1. Taxonomic orders (number/m2) collected with the air-lift sampler (Flathead Lake, 1991). FN=Flathead Lake North Site; FS=Flathead Lake South Site; VZ=varial zone; PWZ=permanently wetted zone.

FH VZ AUG	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-MEAN	S-MEAN	Grand Mean	stdev	se
Amphipoda	146	178	373	535	330	422	97	135	161	270	92	70	331	135	233	138	97.75
Ephemeroptera	1238	1314	659	962	741	432	146	124	141	141	151	135	891	140	515	531	375.68
Trichoptera	141	222	389	114	146	259	0	43	11	32	16	11	208	19	114	134	94.59
Hirudinea	38	43	49	0	11	5	0	5	0	0	0	5	24	2	13	16	11.26
Gastropoda	216	146	151	243	178	81	0	54	0	0	5	16	169	13	91	111	78.38
Plecoptera	22	141	97	103	76	0	0	0	0	0	0	0	73	0	36	52	36.49
Coleoptera	0	22	0	5	0	0	0	11	5	0	0	5	5	4	4	1	0.50
Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Chironomidae	2476	3762	2227	2649	2011	1341	2681	1818	1438	773	995	627	2411	1388	1900	723	511.26
FH VZ OCT	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-MEAN	S-MEAN	Grand Mean	stdev	se
Amphipoda	97	38	103	no count	119	92	54	78	38	32	no count	49	90	50	70	28	20.00
Ephemeroptera	1054	281	1262	no count	638	1124	292	319	222	346	no count	114	892	258	575	448	316.76
Trichoptera	65	97	81	no count	76	76	11	22	5	11	no count	11	79	12	45	47	33.51
Hirudinea	5	49	0	no count	0	5	5	0	6	0	no count	0	12	2	7	7	4.86
Gastropoda	65	27	103	no count	130	70	59	22	5	130	no count	65	79	56	68	16	11.35
Plecoptera	38	0	59	no count	0	43	0	0	0	0	no count	0	28	0	14	20	14.05
Coleoptera	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0.00
Hemiptera	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0.00
Odonata	0	0	0	no count	0	0	0	0	0	0	no count	0	0	0	0	0	0.00
Chironomidae	216	843	319	no count	368	373	205	924	195	205	no count	530	424	412	418	8	5.95
FH PWZ MAY	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-MEAN	S-MEAN	Grand Mean	stdev	se
Amphipoda	768	719	973	703	595	348	243	389	146	395	243	703	684	353	518	234	165.32
Ephemeroptera	108	184	151	130	135	92	81	81	5	65	43	54	133	55	94	55	39.19
Trichoptera	124	146	92	38	114	86	49	130	38	92	103	27	100	73	86	19	13.51
Hirudinea	0	0	0	11	0	38	0	0	0	0	0	0	8	0	4	8	4.05
Gastropoda	32	32	0	27	86	5	11	54	16	27	27	119	31	42	36	8	5.86
Plecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Chironomidae	11854	10373	9173	10281	9000	8454	7348	12195	6135	6822	6016	11600	9523	8386	8954	804	568.43
FH PWZ AUG	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-MEAN	S-MEAN	Grand Mean	stdev	se
Amphipoda	1216	1200	865	957	1011	611	724	541	714	692	573	768	977	668	823	218	154.05
Ephemeroptera	16	11	5	22	16	0	65	49	70	65	38	22	12	51	32	28	19.82
Trichoptera	70	27	27	70	49	86	54	86	27	32	11	27	51	40	45	8	5.86
Hirudinea	0	16	16	81	0	38	0	0	0	0	5	0	25	1	13	17	12.16
Gastropoda	54	114	216	276	49	43	54	149	5	49	27	49	125	55	90	50	35.14
Plecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Chironomidae	22519	23054	16536	25135	15800	20638	18151	13892	21443	9941	16924	11092	20580	15241	17910	3778	2669.82
FH PWZ OCT	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-MEAN	S-MEAN	Grand Mean	stdev	se
Amphipoda	362	578	427	519	811	638	678	703	557	422	405	649	556	568	562	9	6.31
Ephemeroptera	59	97	43	59	43	49	265	162	70	92	141	184	59	152	105	66	46.85
Trichoptera	103	141	114	103	70	97	103	173	92	81	135	86	105	112	108	5	3.60
Hirudinea	11	5	0	16	0	0	0	0	0	0	0	0	5	0	3	4	2.70
Gastropoda	43	49	81	70	76	86	38	141	124	54	103	38	68	83	75	11	7.66
Plecoptera	0	11	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0.90
Coleoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Chironomidae	10108	9811	11119	10605	13032	8292	7724	8941	7822	7016	5861	9724	10495	7851	9173	1869	1321.62

Appendix Table II.2. Taxonomic orders (number/m2) collected with the air-lift sampler (Lake McDonald, 1991). MN=Lake McDonald North Site; MS=Lake McDonald South Site; VZ=varial zone; PWZ=permanently wetted zone.

MCD VZ AUG	MN-A-1	MN-A-2	MN-A-3	MN-A-4	MN-A-5	MN-A-6	MS-A-1	MS-A-2	MS-A-3	MS-A-4	MS-A-5	MS-A-6	N-MEAN	S-MEAN	Grand Mean	stdev	se
Amphipoda	362	427	205	465	568	524	324	205	81	70	168	176	425	171	298	180	127.03
Ephemeroptera	270	303	584	259	570	373	297	270	178	232	368	261	395	271	333	87	61.71
Trichoptera	118	146	108	97	195	114	16	22	11	49	65	38	130	33	82	68	48.20
Hirudinea	27	0	32	22	5	19	5	0	0	0	22	11	17	8	12	8	5.41
Gastropoda	195	86	32	108	65	195	32	16	11	65	86	81	114	49	81	46	32.49
Plecoptera	54	249	238	373	384	373	184	151	27	11	178	130	278	114	196	117	82.43
Coleoptera	130	16	11	38	32	11	11	16	5	32	22	59	40	24	32	11	7.75
Hemiptera	0	5	0	0	0	0	0	5	0	11	5	0	1	4	2	2	1.35
Odonata	0	0	0	0	0	0	0	5	0	0	5	0	0	2	1	1	0.90
Chironomidae	2148	2314	1070	1968	2373	1465	1876	1768	2027	1481	1811	1005	1889	1661	1775	161	113.96
MCD PWZ MAY	**MN-B-1**	**MN-B-2**	**MN-B-3**	**MN-B-4**	**MN-B-5**	**MN-B-6**	**MS-B-1**	**MS-B-2**	**MS-B-3**	**MS-B-4**	**MS-B-5**	**MS-B-6**	**N-MEAN**	**S-MEAN**	**Grand Mean**	**stdev**	**se**
Amphipoda	54	27	27	11	no count	22	5	16	22	5	38	11	28	16	22	8	5.95
Ephemeroptera	205	130	22	59	no count	124	22	32	38	22	11	16	108	23	66	60	42.34
Trichoptera	124	81	49	54	no count	76	97	38	54	32	70	27	77	53	65	17	11.80
Hirudinea	0	0	0	0	no count	0	0	0	0	0	0	0	0	0	0	0	0.00
Gastropoda	59	92	43	38	no count	27	5	32	11	16	16	5	52	14	33	27	18.74
Plecoptera	5	0	0	0	no count	5	0	0	0	0	0	0	2	0	1	2	1.08
Coleoptera	16	16	0	5	no count	0	38	5	16	0	27	0	7	14	11	5	3.47
Hemiptera	0	22	5	5	no count	0	0	0	0	0	0	5	6	1	4	4	2.79
Odonata	0	0	0	0	no count	0	0	0	0	0	5	0	0	1	0	1	0.45
Chironomidae	8562	5832	2535	3076	no count	3427	7335	7178	6638	4611	9168	4692	4686	6937	5812	1591	1125.23
MCD PWZ AUG	**MN-B-1**	**MN-B-2**	**MN-B-3**	**MN-B-4**	**MN-B-5**	**MN-B-6**	**MS-B-1**	**MS-B-2**	**MS-B-3**	**MS-B-4**	**MS-B-5**	**MS-B-6**	**N-MEAN**	**S-MEAN**	**Grand Mean**	**stdev**	**se**
Amphipoda	103	32	103	59	119	124	32	59	5	632	78	59	90	144	117	38	27.03
Ephemeroptera	286	281	76	119	586	161	135	119	27	135	181	178	251	124	188	90	63.51
Trichoptera	168	151	157	124	178	151	70	81	59	108	135	65	155	86	121	48	34.23
Hirudinea	0	8	5	16	0	0	0	0	0	0	11	0	5	2	3	2	1.35
Gastropoda	114	16	38	124	16	65	32	43	22	108	0	16	82	37	50	18	12.81
Plecoptera	11	11	0	5	40	11	0	0	0	0	0	0	14	0	7	10	7.21
Coleoptera	32	141	87	49	162	49	157	124	0	81	184	200	88	124	106	25	18.00
Hemiptera	22	0	0	0	0	0	43	5	0	16	16	5	4	14	9	8	5.41
Odonata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Chironomidae	4335	5973	4714	4376	5632	6005	6935	5995	3454	7973	6858	5819	5173	5989	5581	577	408.11
MCD PWZ OCT	**MN-B-1**	**MN-B-2**	**MN-B-3**	**MN-B-4**	**MN-B-5**	**MN-B-6**	**MS-B-1**	**MS-B-2**	**MS-B-3**	**MS-B-4**	**MS-B-5**	**MS-B-6**	**N-MEAN**	**S-MEAN**	**Grand Mean**	**stdev**	**se**
Amphipoda	54	49	22	11	97	0	11	0	0	0	16	22	39	8	23	22	15.32
Ephemeroptera	336	600	249	378	286	162	281	184	43	351	459	189	335	261	293	59	41.89
Trichoptera	86	254	70	157	157	59	530	157	124	135	205	114	127	211	169	59	41.89
Hirudinea	5	0	5	11	5	0	5	5	0	8	27	16	5	9	7	3	2.25
Gastropoda	54	146	157	146	59	76	189	81	22	98	22	227	106	105	105	1	0.90
Plecoptera	27	81	5	43	16	0	0	0	0	43	43	0	28	14	22	10	7.21
Coleoptera	81	135	27	49	119	11	232	16	43	286	865	341	70	264	167	137	96.75
Hemiptera	65	32	11	0	0	5	0	0	0	0	0	0	19	0	9	13	9.46
Odonata	0	0	0	0	0	0	5	0	5	0	0	5	0	3	1	2	1.35
Chironomidae	2470	2254	3638	1568	3697	2957	10735	7881	3573	6076	11211	8568	2764	8007	5386	3708	2621.62

Appendix Table III.1. Functional feeding groups (number/m2) collected with the air-lift sampler (Flathead Lake,1991). FN=Flathead Lake North Site; FS=Flathead Lake South Site; VZ=varial zone; PWZ=permanently wetted zone.

FH VZ AUG	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-mean	S-mean	Grand mean	stdev	se
Shredders (Erosional)	65	254	368	168	141	108	0	0	0	5	0	0	184	1	92	129	91
Grazers (Erosional)	195	189	86	141	135	49	5	5	5	5	5	0	132	5	68	90	64
Grazers (Depositional)	0	5	0	0	0	16	0	0	0	0	0	0	4	0	2	3	2
Collectors (Erosional)	1141	1195	627	849	643	492	141	135	146	151	146	135	824	142	483	482	341
Collectors (Depositional)	2476	3773	2227	2649	2011	1346	2681	1816	1438	773	995	627	2414	1388	1901	725	513
Predators (Erosional)	0	22	0	5	0	22	0	22	5	5	11	16	8	10	9	1	1
Predators (Depositional)	70	130	97	70	81	59	76	114	59	49	65	32	85	66	75	13	9
FH VZ OCT	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-mean	S-mean	Grand mean	stdev	se
Shredders (Erosional)	38	59	59	no count	22	49	0	0	0	0	no count	0	45	0	23	32	23
Grazers (Erosional)	314	151	314	no count	265	303	227	141	184	270	no count	81	269	181	225	63	44
Grazers (Depositional)	0	5	0	no count	0	0	0	11	5	0	no count	5	1	4	3	2	2
Collectors (Erosional)	757	135	1049	no count	373	838	65	178	38	76	no count	32	630	78	354	391	276
Collectors (Depositional)	216	843	319	no count	368	373	205	924	195	205	no count	530	424	412	418	8	6
Predators (Erosional)	49	22	81	no count	54	54	11	11	0	5	no count	5	52	6	29	32	23
Predators (Depositional)	43	27	16	no count	no count	162	no count	no count	no count	no count	no count	no count	no count	no count	64	—	—
FH PWZ MAY	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-mean	S-mean	Grand mean	stdev	se
Shredders (Erosional)	0	0	0	0	0	5	0	0	0	0	0	0	1	0	1	1	1
Grazers (Erosional)	65	86	92	22	119	54	49	11	5	22	5	11	73	17	45	39	28
Grazers (Depositional)	22	49	5	0	0	0	5	59	22	59	43	0	13	32	22	13	9
Collectors (Erosional)	38	32	6	5	32	17	0	0	0	22	0	5	22	5	13	12	9
Collectors (Depositional)	11914	10497	9264	10400	9049	6513	7383	12271	6140	8854	6102	11849	9606	8433	9020	829	586
Predators (Erosional)	11	5	11	11	27	27	22	11	5	0	0	0	15	6	11	6	5
Predators (Depositional)	368	362	308	314	265	211	211	324	114	249	157	281	305	223	264	58	41
FH PWZ AUG	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-mean	S-mean	Grand mean	stdev	se
Shredders (Erosional)	0	0	0	0	0	5	0	5	0	0	0	0	1	1	1	1	1
Grazers (Erosional)	32	5	0	22	27	22	5	5	0	5	5	0	18	4	11	10	7
Grazers (Depositional)	5	5	11	0	0	0	0	0	0	5	0	0	4	1	2	2	1
Collectors (Erosional)	32	16	11	32	22	22	27	22	38	43	16	16	23	27	25	3	2
Collectors (Depositional)	22519	23059	16541	25151	15600	20638	18205	13919	21481	9968	16941	11108	20585	15270	17927	3758	2657
Predators (Erosional)	11	0	5	22	16	16	22	54	16	11	5	5	12	19	15	5	4
Predators (Depositional)	200		259	232			503	357	384	378	254	314	230	365	298	95	67
FH PWZ OCT	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-mean	S-mean	Grand mean	stdev	se
Shredders (Erosional)	0	11	0	0	0	0	0	0	0	0	0	0	2	0	1	1	1
Grazers (Erosional)	32	22	69	22	11	11	5	0	0	0	5	0	26	2	14	17	12
Grazers (Depositional)	32	11	5	5	0	22	22	97	11	27	32	16	13	34	23	15	11
Collectors (Erosional)	32	119	32	43	49	32	5	11	11	11	0	5	51	7	29	31	22
Collectors (Depositional)	10124	9832	11141	10622	13032	8314	7984	9092	7892	7103	6016	9908	10511	7999	9255	1776	1256
Predators (Erosional)	0	22	0	5	0	16	22	22	0	0	0	11	7	9	8	1	1
Predators (Depositional)	335	195	157	200	346	178	389	259	308	249	373	389	235	328	282	66	46

Appendix Table III.2. Functional feeding groups (number/m2) collected with the air-lift sampler (Lake McDonald, 1991). MN=Lake McDonald North Site; MS=Lake McDonald South Site; VZ=varial zone; PWZ=permanently wetted zone.

MCD VZ AUG	MN-A-1	MN-A-2	MN-A-3	MN-A-4	MN-A-5	MN-A-6	MS-A-1	MS-A-2	MS-A-3	MS-A-4	MS-A-5	MS-A-6	N-mean	S-mean	Grand mean	stdev	se
Shredders (Erosional)	157	368	335	459	530	405	195	157	32	38	184	141	376	124	250	178	126
Grazers (Erosional)	16	16	22	27	70	32	22	27	22	27	11	38	31	24	27	4	3
Grazers (Depositional)	5	0	0	5	0	0	0	5	0	22	16	43	2	14	8	9	6
Collectors (Erosional)	238	281	551	227	530	335	265	254	157	211	341	254	360	247	304	80	57
Collectors (Depositional)	2173	2346	1092	1978	2384	1503	1892	1773	2032	1497	1838	1016	1913	1675	1794	168	119
Predators (Erosional)	130	22	11	38	49	59	11	16	5	22	59	22	51	23	37	20	14
Predators (Depositional)	22	49	11	11	11	16	27	16	27	11	16	49	20	24	22	3	2
MCD PWZ MAY	**MN-B-1**	**MN-B-2**	**MN-B-3**	**MN-B-4**	**MN-B-5**	**MN-B-6**	**MS-B-1**	**MS-B-2**	**MS-B-3**	**MS-B-4**	**MS-B-5**	**MS-B-6**	**N-mean**	**S-mean**	**Grand mean**	**stdev**	**se**
Shredders (Erosional)	54	5	38	0	no count	49	22	0	0	0	27	11	29	10	20	14	10
Grazers (Erosional)	103	103	11	5	no count	49	5	22	11	11	5	16	54	12	33	30	21
Grazers (Depositional)	0	5	0	0	no count	0	49	27	43	32	49	0	1	33	17	23	16
Collectors (Erosional)	11	5	0	0	no count	0	0	6	5	0	5	0	3	3	3	0	0
Collectors (Depositional)	8697	5908	2557	3162	no count	3524	7373	7183	8665	4622	9178	4697	4770	6953	5861	1544	1092
Predators (Erosional)	27	38	5	32	no count	5	0	0	5	0	0	5	22	2	12	14	10
Predators (Depositional)	373	600	265	254	no count	357	416	465	535	254	514	227	370	402	386	23	16
MCD PWZ AUG	**MN-B-1**	**MN-B-2**	**MN-B-3**	**MN-B-4**	**MN-B-5**	**MN-B-6**	**MS-B-1**	**MS-B-2**	**MS-B-3**	**MS-B-4**	**MS-B-5**	**MS-B-6**	**N-mean**	**S-mean**	**Grand mean**	**stdev**	**se**
Shredders (Erosional)	54	16	59	27	32	54	22	11	43	16	32	5	41	22	31	13	9
Grazers (Erosional)	65	65	49	16	76	27	11	11	16	22	11	11	50	14	32	25	18
Grazers (Depositional)	11	130	92	43	162	27	157	103	0	65	178	184	77	114	96	26	18
Collectors (Erosional)	276	265	76	103	470	151	103	114	11	108	135	162	223	105	164	83	59
Collectors (Depositional)	4357	6011	4751	4427	5778	6011	6978	6011	3470	8022	5692	5951	5223	6021	5622	564	399
Predators (Erosional)	54	22	5	11	49	32	43	27	0	59	59	22	29	35	32	4	3
Predators (Depositional)	141	146	227	184	216	162	114	114	124	97	162	124	179	123	151	40	28
MCD PWZ OCT	**MN-B-1**	**MN-B-2**	**MN-B-3**	**MN-B-4**	**MN-B-5**	**MN-B-6**	**MS-B-1**	**MS-B-2**	**MS-B-3**	**MS-B-4**	**MS-B-5**	**MS-B-6**	**N-mean**	**S-mean**	**Grand mean**	**stdev**	**se**
Shredders (Erosional)	22	97	22	54	16	5	5	27	27	49	97	0	36	34	35	1	1
Grazers (Erosional)	27	135	11	114	11	27	0	0	0	49	5	0	54	9	32	32	23
Grazers (Depositional)	81	124	22	49	119	11	719	86	86	378	697	389	68	393	230	230	163
Collectors (Erosional)	157	314	178	195	119	103	27	157	38	303	249	103	177	146	162	22	16
Collectors (Depositional)	2627	2416	3697	1643	3859	2995	10989	7908	3578	6081	11422	8654	2873	8105	5489	3700	2616
Predators (Erosional)	86	65	27	11	22	27	5	11	22	11	43	27	40	20	30	14	10
Predators (Depositional)	368	319	162	184	141	211	232	200	200	151	189	276	231	208	219	16	11

Appendix Table IV.1. ANOVA for taxonomic orders of Flathead Lake and Lake McDonald (Varial Zone); *LAKE treated as a fixed factor; **LAKE treated as a random factor.

Varial Zone	square root-transformed data				
Chironomidae	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Lake	1.7	1.0	1.7	0.029	*0.867
Site {lake}	482.0	2.0	241.0	4.190	0.030
Error	1151.0	20.0	57.6		
Lake				0.007	**0.942
Ephemeroptera					
Lake	41.0	1.0	41.0	3.100	*0.093
Site {lake}	954.0	2.0	477.0	36.200	0.000
Error	264.0	20.0	13.0		
Lake				0.086	**0.797
Trichoptera					
Lake	1.8	1.0	1.8	0.340	*0.567
Site {lake}	420.0	2.0	210.0	39.900	0.000
Error	105.0	20.0	5.0		
Lake				0.009	**0.935
Plecoptera					
Lake	510.0	1.0	510.0	33.300	*0.000
Site {lake}	289.0	2.0	145.0	9.400	0.001
Error	306.0	20.0	15.0		
Lake				3.500	**0.201
Coleoptera					
Lake	91.0	1.0	91.0	19.100	*0.000
Site {lake}	3.0	2.0	1.7	0.350	0.708
Error	95.0	20.0	4.8		
Lake				54.400	**0.018
Hemiptera					
Lake	4.2	1.0	4.2	5.600	*0.029
Site {lake}	2.6	2.0	1.3	1.700	0.207
Error	15.0	20.0	0.8		
Lake				3.260	**0.213
Amphipoda					
Lake	24.0	1.0	23.0	1.900	*0.189
Site {lake}	302.0	2.0	151.0	12.000	0.000
Error	251.0	20.0	12.6		
Lake				0.154	**0.733
Gastropoda					
Lake	4.2	1.0	4.2	0.528	*0.476
Site {lake}	375.0	2.0	188.0	23.600	0.000
Error	159.0	20.0	8.0		
Lake				0.022	**0.895
Hirudinea					
Lake	0.2	1.0	0.2	0.048	*0.829
Site {lake}	47.2	2.0	23.6	5.300	0.895
Error	89.7	20.0	4.5		
Lake				0.009	**0.932

Appendix Table IV.2. ANOVA of taxonomic groups of Flathead Lake and Lake McDonald (Permanently Wetted Zone); *LAKE treated as a fixed factor; **LAKE treated as a random factor.

Permanent Wet Zone	square root-	transformed			
Chironomidae	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Lake	20791	1	20791.00	133.741	*0.000
Date	6397	2	3198.50	20.5747	0.000
Lake x Date	5264	2	2632.00	16.9307	0.000
Site (Lake)	4838	2	2419.00	15.5605	0.000
Date* Site (Lake)	1771	4	442.75	2.84804	0.031
Error	9172	59	155.46		
Lake					**0.099
Lake x Date				5.9	**0.063
Ephemeroptera					
Lake	315	1	315.00	31.715	*0.000
Date	334	2	167.00	16.814	0.000
Lake x Date	336	2	168.00	16.9147	0.000
Site (Lake)	156	2	78.00	7.85324	0.000
Date* Site (Lake)	160	4	40.00	4.0273	0.006
Error	586	59	9.93		
Lake				4	**0.182
Lake x Date				4.2	**0.104
Trichoptera					
Lake	53	1	53.00	10.1197	*0.002
Date	124	2	62.00	11.8382	0.000
Lake x Date	88	2	44.00	8.40129	0.001
Site (Lake)	8	2	4.00	0.76375	0.456
Date* Site (Lake)	68	4	17.00	3.24595	0.017
Error	309	59	5.24		
Lake				12.6	**0.071
Lake x Date				2.6	**0.191
Plecoptera					
Lake	51	1	51.00	19.9272	*0.000
Date	31	2	15.50	6.05629	0.004
Lake x Date	21	2	10.50	4.10265	0.022
Site (Lake)	30	2	15.00	5.86093	0.004
Date* Site (Lake)	15	4	3.75	1.46523	0.216
Error	151	59	2.56		
Lake				3.3	**0.21
Lake x Date				2.7	**0.179
Coleoptera					
Lake	1058	1	1058.00	102.837	*0.000
Date	247	2	123.50	12.0041	0.000
Lake x Date	242	2	121.00	11.7611	0.000
Site (Lake)	71	2	35.50	3.45058	0.038
Date* Site (Lake)	64	4	16.00	1.55519	0.201
Error	607	59	10.29		
Lake				29.7	**0.032
Lake x Date				7.8	**0.042

Appendix Table IV.2. ANOVA for taxonomic orders of Flathead Lake and Lake McDonald (Permanently Wetted Zone); *LAKE treated as a fixed factor; **LAKE treated as a random factor.

Hemiptera					
Lake	43	1	43.00	22.4513	*0.000
Date	2	2	1.00	0.52212	0.561
Lake x Date	2	2	1.00	0.52212	0.561
Site (Lake)	5	2	2.50	1.30531	0.277
Date* Site (Lake)	49	4	12.25	6.39602	0.000
Error	113	59	1.92		
Lake					**0.054
Lake x Date					**0.914
Amphipoda					
Lake	6276	1	6276.00	439.246	*0.000
Date	478	2	239.00	16.7272	0.000
Lake x Date	15	2	7.50	0.52491	0.586
Site (Lake)	177	2	88.50	6.19395	0.004
Date* Site (Lake)	120	4	30.00	2.09964	0.092
Error	843	59	14.29		
Lake				70.7	**0.014
Lake x Date				0.256	**0.786
Gastropoda					
Lake	3	1	3.00	0.33714	*0.597
Date	169	2	84.50	9.49619	0.000
Lake x Date	41	2	20.50	2.30381	0.111
Site (Lake)	41	2	20.50	2.30381	0.111
Date* Site (Lake)	55	4	13.75	1.54524	0.198
Error	525	59	8.90		
Lake				0.124	**0.759
Lake x Date				1.46	**0.333
Hirudinea					
Lake	1	1	1.00	0.34503	*0.541
Date	18	2	9.00	3.10526	0.051
Lake x Date	19	2	9.50	3.27778	0.047
Site (Lake)	44	2	22.00	7.59064	0.001
Date* Site (Lake)	11	4	2.75	0.94883	0.467
Error	171	59	2.90		
Lake				0.049	**0.845
Lake x Date				3.5	**0.13

Appendix Table V.1. ANOVA for functional feeding groups of Flathead Lake and Lake McDonald (Varial Zone); *LAKE treated as a fixed factor; **LAKE treated as a random factor.

Varial Zone	square root-transformed data				
Shredders (erosional)	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Lake	398	1	398.000	36.347	*0.000
Site (Lake)	699	2	349.500	31.918	0.000
Error	219	20	10.950		
Lake	398			1.139	**0.398
error: Site (Lake)	699				
Grazers (erosional)					
Lake	13	1	13.000	4.483	*0.049
Site (Lake)	265	2	132.500	45.690	0.000
Error	58	20	2.900		
Lake	13			0.098	**0.786
error: Site (Lake)	265				
Collectors (erosional)					
Lake	54	1	54.000	5.000	*0.037
Site (Lake)	837	2	418.500	38.750	0.000
Error	216	20	10.800		
Lake	54			0.129	**0.754
error: Site (Lake)	837				
Predators (erosional)					
Lake	62.6	1	62.600	13.042	*0.002
Site (Lake)	17.5	2	8.750	1.823	0.188
Error	96	20	4.800		
Lake	62			7.170	**0.116
error: Site (Lake)	17				
Grazers (depositional)					
Lake	10	1	10.000	3.571	*0.07
Site (Lake)	17	2	8.500	3.036	0.068
Error	56	20	2.800		
Lake	10			1.187	**0.39
error: Site (Lake)	17				
Collectors (depositional)					
Lake	0.6	1	0.600	0.010	*0.92
Site (Lake)	486	2	243.000	4.241	0.029
Error	1146	20	57.300		
Lake	0.6			0.002	**0.965
error: Site (Lake)	486				
Predators (depositional)					
Lake	96	1	96.000	45.714	*0.000
Site (Lake)	4.7	2	2.350	1.119	0.347
Error	42	20	2.100		
Lake	96			40.851	**0.024
error: Site (Lake)	4.7				

Appendix Table V.2. ANOVA of functional feeding groups of Flathead Lake and Lake McDonald (Permanently Wetted Zone); *LAKE treated as a fixed factor; **LAKE treated as a random factor.

Permanent Wet Zone	square root-transformed data				
Shredders (erosional)	Sum of Squares	Degrees of Freedom	Mean Square	F-ratio	P-value
Lake	334	1	334	91.6558	*0.000
Date	15.8	2	7.9	2.16791	0.123
Lake x Date	12	2	6	1.64651	0.211
Site (Lake)	22	2	11	3.0186	0.055
Date * Site (Lake)	5	4	1.25	0.34302	0.831
Error	215	59	3.6440678		
Lake				30.06	**0.032
Date				5.9	**0.064
Lake * Date					**0.099
Grazers (erosional)					
Lake	14.8	1	14.8	3.16377	*0.081
Date	53.9	2	26.95	5.76105	0.005
Lake x Date	42	2	21	4.48913	0.015
Site (Lake)	246	2	123	26.2935	0.000
Date * Site (Lake)	15	4	3.75	0.80163	0.525
Error	276	59	4.6779661		
Lake				0.12	**0.762
Date				7.1	**0.048
Lake * Date					**0.07
Collectors (erosional)					
Lake	334	1	334	46.6967	*0.000
Date	651	2	325.5	45.5083	0.000
Lake x Date	312	2	156	21.8104	0.000
Site (Lake)	92	2	46	6.43128	0.003
Date * Site (Lake)	69	4	17.25	2.41173	0.059
Error	422	59	7.15254237		
Lake				7.3	**0.115
Date				18.9	**0.009
Lake * Date					**0.033
Predators (erosional)					
Lake	41	1	41	10.4267	*0.002
Date	34	2	17	4.32328	0.017
Lake x Date	33	2	16.5	4.19612	0.021
Site (Lake)	25	2	12.5	3.17888	0.048
Date * Site (Lake)	36	4	9	2.28879	0.073
Error	232	59	3.93220339		
Lake				3.3	**0.213
Date				1.9	**0.260
Lake * Date				1.8	**0.273

Appendix Table V.2 (continued). ANOVA of functional feeding groups of Flathead Lake and Lake McDonald (Permanently Wetted Zone); *LAKE treated as a fixed factor; **LAKE treated as a random factor.

Grazers (depositional)					
Lake	514	1	514	40.3271	*0.000
Date	369	2	184.5	14.4754	0.000
Lake x Date	326	2	163	12.7886	0.000
Site (Lake)	298	2	149	11.6902	0.000
Date * Site (Lake)	157	4	39.25	3.07945	0.023
Error	752	59	12.7457627		
Lake				3.4	**0.205
Date				4.7	**0.089
Lake * Date				4.16	**0.1052
Collectors (depositional)					
Lake	20624	1	20624	132.119	*0.000
Date	6155	2	3077.5	19.7147	0.000
Lake x Date	5274	2	2637	16.8928	0.000
Site (Lake)	4673	2	2336.5	14.9678	0.000
Date * Site (Lake)	1705	4	426.25	2.73059	0.037
Error	9210	59	156.101695		
Lake				8.8	**0.097
Date				7.2	**0.047
Lake * Date					**0.06
Predators (depositional)					
Lake	22	1	22	4.28383	*0.048
Date	107	2	53.5	10.4175	0.000
Lake x Date	186	2	93	18.1089	0.000
Site (Lake)	18	2	9	1.75248	0.193
Date * Site (Lake)	81	4	20.25	3.94307	0.009
Error	303	59	5.13559322		
Lake				2.4	**0.261
Date				2.6	**0.187
Lake * Date				4.6	**0.092

Appendix Table VI. Periphyton analyses (Ash-free dry weight) of Flathead Lake and Lake McDonald, August 1991. MCD=Lake McDonald; FH=Flathead Lake; VZ=varial zone; PWZ=permanently wetted zone.

Site	Area (cm2)	Dry wt. (g)	Ash wt. (g)	Ash-free wt. (g)	AFDW (g/m2)	Mean	stdev	se
MCD VZ NORTH	25	0.1405	0.1277	0.0128	5.120			
	25	0.1058	0.0908	0.015	6.000			
	25	0.1355	0.1143	0.0212	8.480			
	25	0.1671	0.1483	0.0188	7.520			
	25	0.1092	0.0867	0.0225	9.000	7.22	1.64	0.73
MCD VZ SOUTH	25	0.0797	0.0745	0.0052	2.080			
	25	0.0932	0.0749	0.0183	7.320			
	25	0.0794	0.0721	0.0073	2.920			
	25	0.1024	0.089	0.0134	5.360			
	25	0.0866	0.0771	0.0095	3.800	4.30	2.08	0.93
MCD PWZ NORTH	25	0.1268	0.1053	0.0215	8.600			
	25	0.0977	0.0931	0.0046	1.840			
	25	0.1387	0.1269	0.0118	4.720			
	25	0.0857	0.0716	0.0141	5.640			
	25	0.1303	0.1077	0.0226	9.040	5.97	2.96	1.32
MCD PWZ SOUTH	25	0.1386	0.1112	0.0274	10.960			
	25	0.1567	0.1485	0.0082	3.280			
	25	0.0731	0.0692	0.0039	1.560			
	25	0.0732	0.0693	0.0039	1.560			
	25	0.075	0.0713	0.0037	1.480	3.77	4.09	1.83
FH VZ NORTH	25	0.1566	0.1397	0.0169	6.760			
	25	0.1338	0.113	0.0208	8.320			
	25	0.1343	0.0983	0.036	14.400			
	25	0.1466	0.0993	0.0473	18.920			
	25	0.1502	0.1127	0.0375	15.000	12.68	5.03	2.91
FH VZ SOUTH	25	0.0769	0.0757	0.0012	0.480			
	25	0.0664	0.0651	0.0013	0.520			
	25	0.065	0.064	0.001	0.400			
	25	0.0633	0.0621	0.0012	0.480			
	25	0.055	0.041	0.014	5.600	1.50	2.29	1.03
FH PWZ NORTH	25	0.4355	0.383	0.0525	21.000			
	25	0.969	0.9155	0.0535	21.400			
	25	0.6785	0.6286	0.0499	19.960			
	25	0.6934	0.6233	0.0701	28.040			
	25	0.8524	0.8112	0.0412	16.480	21.38	4.20	1.878
FH PWZ SOUTH	25	0.5395	0.4681	0.0714	28.560			
	25	1.5685	1.4861	0.0824	32.960			
	25	1.211	1.1843	0.0267	10.680			
	25	1.8646	1.765	0.0996	39.840			
	25	1.035	0.8981	0.1369	54.760	33.36	16.11	7.203
	GRAND MEAN	stdev	se					
MCD VZ	5.760	0.207	0.146					
MCD PWZ	4.868	0.155	0.110					
FH VZ	7.088	0.791	0.559					
FH PWZ	27.368	0.847	0.599					

Appendix Table VII. Total benthic organic matter (Ash-free dry weight) collected with the air-lift sampler (Lake McDonald, August 1991). MCD=Lake McDonald; VZ=varial zone; PWZ=permanently wetted zone.

Site	Sample area (m2)	Dry weight (g)	Ash weight (g)	Ash-free wt (g)	sub sample factor	AFDW (g/m2)	Mean	stdev	se
MCD VZ NORTH	0.185	8.2	2.2	6	2	64.86			
	0.185	7.1	2.9	4.2	2	45.41			
	0.185	2.9	0.8	2.1	4	45.41			
	0.185	7.3	1.8	5.5	4	118.92			
	0.185	4.4	3.3	1.1	2	11.89	57.297	39.3668	17.6
MCD VZ SOUTH	0.185	1.1	0.4	0.7	1	3.78			
	0.185	2.2	1.9	0.3	2	3.24			
	0.185	0.4	0.2	0.2	1	1.08			
	0.185	0.9	0.6	0.3	1	1.62	2.4324	1.28674	0.64
MCD PWZ NORTH	0.185	3.9	3.1	0.8	2	8.65			
	0.185	5.7	4.7	1	2.67	14.43			
	0.185	10	8	2	2.67	26.86			
	0.185	8.7	6.8	1.9	2.67	27.42			
	0.185	4.5	3.1	1.4	2.67	20.21	19.915	8.56626	3.83
MCD PWZ SOUTH	0.185	9.9	7.3	2.6	2.67	37.52			
	0.185	4.2	2.9	1.3	2.67	18.76			
	0.185	7.1	5.4	1.7	2.67	24.54			
	0.185	2.7	1.9	0.8	2	8.65			
	0.185	10.2	8.1	2.1	2.67	30.31			
	0.185	1.6	0.9	0.7	2	7.57	21.224	11.9154	4.86
	mean	se							
MCD VZ	29.86	27.5							
MCD PWZ	20.57	0.656							

Appendix Table VIII.1. Trichoptera (numbers/m2) which construct cases from plant fragments or minerals (Flathead Lake, 1991).
FN=Flathead Lake North Site; FS=Flathead Lake South Site; VZ=varial zone; PWZ=permanently wetted zone.

FH VZ AUG	Case	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-Mean	S-Mean	Grand Mean	stdev	se
Hydroptila	stone	0	5	0	0	0	16	0	0	0	0	0	0					
Lepidostoma	plant	43	114	270	65	65	108	0	0	0	5	0	0					
Ceraclea	stone	88	70	54	27	38	108	0	16	11	16	0	0					
Mystacides	plant/stone	0	11	0	0	0	5	0	0	0	0	0	0					
Oecetis	stone	0	0	0	0	0	22	0	11	0	5	11	11					
Immature	plant/stone	0	0	0	0	0	0	0	0	0	0	0	0					
Amphicosmoecus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Anabolia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Apatania	stone	0	0	0	0	0	0	0	0	0	0	0	0					
Clistoronia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Psychoglypha	plant	11	0	0	0	0	0	0	0	0	0	0	0					
Limnephilus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Molanna	stone	0	0	0	0	0	0	0	0	0	0	0	0					
Total Stone Cases		88	76	54	27	38	146	0	27	11	22	11	11	71	14	42	41	29
Total Plant Cases		54	124	270	65	65	114	0	0	0	5	0	0	115	1	58	81	57
FH VZ OCT	Case	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-Mean	S-Mean	Grand Mean	stdev	se
Hydroptila	stone	0	5	0		0	0	0	11	5	0		5					
Lepidostoma	plant	0	59	0		22	5	0	0	0	0		0					
Ceraclea	stone	16	5	0		0	16	0	0	0	0		0					
Mystacides	plant/stone	0	0	0		0	0	0	0	0	0		0					
Oecetis	stone	49	22	81		54	54	11	11	0	5		5					
Immature	plant/stone	0	0	0		0	0	0	0	0	0		0					
Amphicosmoecus	plant	0	0	0		0	0	0	0	0	0		0					
Anabolia	plant	0	0	0		0	0	0	0	0	0		0					
Apatania	stone	0	0	0		0	0	0	0	0	0		0					
Clistoronia	plant	0	0	0		0	0	0	0	0	0		0					
Psychoglypha	plant	0	0	0		0	0	0	0	0	0		0					
Limnephilus	plant	0	0	0		0	0	0	0	0	0		0					
Molanna	stone	0	0	0		0	0	0	0	0	0		0					
Total Stone Cases		65	32	81		54	70	11	22	5	5		11	61	11	36	35	25
Total Plant Cases		0	59	0		22	5	0	0	0	0		0	17	0	8	12	8
FH PWZ MAY	Case	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-Mean	S-Mean	Grand Mean	stdev	se
Hydroptila	stone	22	48	0	0	0	0	5	59	22	59	43	0					
Lepidostoma	plant	0	0	0	0	0	5	0	0	0	0	0	0					
Ceraclea	stone	38	32	5	5	32	11	0	0	0	0	0	0					
Mystacides	plant/stone	5	0	16	5	11	16	0	0	0	0	49	11					
Oecetis	stone	11	5	11	11	27	27	22	11	5	0	0	0					
Immature	plant/stone	0	0	0	0	0	0	0	0	0	0	0	0					
Amphicosmoecus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Anabolia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Apatania	stone	11	32	16	5	22	11	5	5	5	11	0	0					
Clistoronia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Psychoglypha	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Limnephilus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Molanna	stone	0	0	5	0	0	0	0	0	0	0	0	0					
Total Stone Cases		81	119	38	22	81	49	32	76	32	70	43	0	65	42	54	16	11
Total Plant Cases		5	0	16	5	11	22	0	0	0	0	49	11	10	10	10	0	0

Appendix Table VIII.1 (continued). Trichoptera (numbers/m2) which construct cases from plant fragments or minerals (Flathead Lake, 1991). FN=Flathead Lake North Site; FS=Flathead Lake South Site; VZ=varial zone; PWZ=permanently wetted zone.

FN PWZ AUG	Case	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-Mean	S-Mean	Grand Mean	stdev	se
Hydroptila	stone	5	0	0	0	0	0	0	0	0	5	0	0					
Lepidostoma	plant	0	0	0	0	0	5	0	5	0	0	0	0					
Ceraclea	stone	32	11	11	22	22	22	11	0	5	5	0	11					
Mystacides	plant/stone	0	5	0	11	0	0	5	0	0	0	0	0					
Oecetis	stone	11	0	5	22	16	16	22	54	16	11	5	5					
Immature	plant/stone	0	0	0	0	0	0	0	0	0	0	0	0					
Amphicosmoecus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Anabolia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Apatania	stone	16	0	0	16	11	22	5	5	0	5	0	0					
Ciistoronia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Psychoglypha	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Limnephilus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Molanna	stone	0	5	11	0	0	0	0	0	0	0	0	0					
Total Stone Cases		65	16	27	59	49	59	38	59	22	27	5	16	46	26	37	13	9
Total Plant Cases		0	5	0	11	0	5	5	5	0	0	0	0	4	2	3	1	1
FN PWZ OCT	Case	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-Mean	S-Mean	Grand Mean	stdev	se
Hydroptila	stone	32	11	5	5	0	22	22	97	11	27	32	16					
Lepidostoma	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Ceraclea	stone	22	65	16	22	16	11	5	0	11	5	0	0					
Mystacides	plant/stone	0	0	0	0	0	0	0	0	0	0	0	5					
Oecetis	stone	0	22	0	5	0	16	22	22	0	0	0	11					
Immature	plant/stone	0	0	0	0	0	0	0	0	0	0	0	0					
Amphicosmoecus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Anabolia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Apatania	stone	0	0	54	0	0	5	0	0	0	0	0	0					
Ciistoronia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Psychoglypha	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Limnephilus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Molanna	stone	0	0	0	0	0	0	0	0	0	0	0	0					
Total Stone Cases		54	97	76	32	16	54	49	119	22	32	32	27	55	47	51	6	4
Total Plant Cases		0	0	0	0	0	0	0	0	0	0	0	5	0	1	0	1	0
	Littoral Mean	stdev	se															
STONE CASES	44	21	7															
PLANT CASES	16	35	11															

Appendix Table VIII.2. Trichoptera (numbers/m2) which construct cases from plant fragments or minerals (Lake McDonald, 1991). MN=Lake McDonald North Site; MS=Lake McDonald South Site; VZ=varial zone; PWZ=permanently wetted zone.

MCD VZ AUG	Case	MN-A-1	MN-A-2	MN-A-3	MN-A-4	MN-A-5	MN-A-6	MS-A-1	MS-A-2	MS-A-3	MS-A-4	MS-A-5	MS-A-6	N-Mean	S-Mean	Grand Mean	stdev	se
Hydroptila	stone	0	0	0	0	0	0	0	0	0	0	0	0					
Lepidostoma	plant	108	119	97	92	162	81	11	5	5	22	11	16					
Ceraclea	stone	0	0	0	0	0	5	0	0	0	0	0	0					
Mystacides	plant/stone	11	22	5	0	5	16	5	5	5	5	11	5					
Oecetis	stone	0	0	0	0	0	0	0	0	0	0	43	0					
Immature	plant/stone	0	0	0	0	0	0	0	0	0	0	0	0					
Amphicosmoecus	plant	0	0	0	0	0	0	0	0	0	5	0	0					
Anabolia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Apatania	stone	0	5	5	5	27	11	0	11	0	16	0	16					
Clistoronia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Psychoglypha	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Limnephilus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Molanna	stone	0	0	0	0	0	0	0	0	0	0	0	0					
Total Stone Cases		0	5	5	5	27	16	0	11	0	16	43	16	10	14	12	3	2
Total Plant Cases		119	141	103	92	168	97	16	11	11	32	22	22	120	19	69	71	50
MCD PWZ MAY	Case	MN-A-1	MN-A-2	MN-A-3	MN-A-4	MN-A-5	MN-A-6	MS-A-1	MS-A-2	MS-A-3	MS-A-4	MS-A-5	MS-A-6	N-Mean	S-Mean	Grand Mean	stdev	se
Hydroptila	stone	0	0	0	0		0	11	22	27	32	22	0					
Lepidostoma	plant	54	5	38	0		49	22	0	0	0	27	11					
Ceraclea	stone	11	5	0	0		0	0	0	0	0	0	0					
Mystacides	plant/stone	11	27	0	32		11	16	0	0	0	0	5					
Oecetis	stone	5	5	0	22		0	0	0	5	0	0	0					
Immature	plant/stone	0	0	0	0		0	0	0	0	0	0	0					
Amphicosmoecus	plant	0	0	0	0		0	0	0	0	0	0	0					
Anabolia	plant	0	0	0	0		0	0	0	0	0	0	0					
Apatania	stone	16	22	11	0		11	5	0	5	0	5	0					
Clistoronia	plant	5	0	0	0		0	0	0	0	0	5	0					
Psychoglypha	plant	0	0	0	0		0	0	0	0	0	0	0					
Limnephilus	plant	0	0	0	0		0	0	0	0	0	0	0					
Molanna	stone	0	0	0	0		0	0	0	0	0	0	0					
Total Stone Cases		32	32	11	22		11	16	22	38	32	27	0	22	23	22	1	0
Total Plant Cases		70	32	38	32		59	38	0	0	0	32	16	46	14	30	23	16
MCD PWZ AUG	Case	MN-A-1	MN-A-2	MN-A-3	MN-A-4	MN-A-5	MN-A-6	MS-A-1	MS-A-2	MS-A-3	MS-A-4	MS-A-5	MS-A-6	N-Mean	S-Mean	Grand Mean	stdev	se
Hydroptila	stone	0	0	0	0	0	0	0	0	0	0	0	0					
Lepidostoma	plant	49	16	59	27	32	54	22	11	43	16	32	6					
Ceraclea	stone	0	0	0	0	0	0	0	0	0	0	0	0					
Mystacides	plant/stone	11	27	38	32	32	5	16	16	11	27	16	22					
Oecetis	stone	0	0	0	0	0	0	0	0	0	27	38	0					
Immature	plant/stone	0	0	0	0	0	0	0	0	0	0	0	0					
Amphicosmoecus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Anabolia	plant	5	0	0	0	0	0	0	0	0	0	0	0					
Apatania	stone	65	59	49	16	65	27	5	5	5	16	11	5					
Clistoronia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Psychoglypha	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Limnephilus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Molanna	stone	0	0	0	0	0	0	0	0	0	0	0	0					
Total Stone Cases		65	59	49	16	65	27	5	5	5	43	49	5	47	19	33	20	14
Total Plant Cases		65	43	97	59	65	59	38	27	54	43	49	27	65	40	52	16	13

Appendix Table VIII.2 (continued). Trichoptera (numbers/m2) which construct cases from plant fragments or minerals (Lake McDonald, 1991). MN=Lake McDonald North Site; MS=Lake McDonald South Site; VZ=varial zone; PWZ=permanently wetted zone.

MCD PWZ OCT	Case	MN-A-1	MN-A-2	MN-A-3	MN-A-4	MN-A-5	MN-A-6	MS-A-1	MS-A-2	MS-A-3	MS-A-4	MS-A-5	MS-A-6	N-Mean	S-Mean	Grand Mean	stdev	se
Hydroptila	stone	0	0	0	0	0	0	486	76	43	92	43	49					
Lepidostoma	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Ceraclea	stone	0	0	0	5	5	5	0	0	0	0	0	0					
Mystacides	plant/stone	5	5	0	0	0	0	0	0	0	0	5	0					
Oecetis	stone	11	22	11	11	11	22	5	5	22	11	32	27					
Immature	plant/stone	27	184	43	86	97	11	0	0	0	0	0	0					
Amphicosmoecus	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Anabolia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Apatania	stone	0	5	0	0	0	0	0	0	0	5	0	0					
Clistoronia	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Psychoglypha	plant	0	0	0	0	0	0	0	0	0	0	0	0					
Limnephilus	plant	5	16	16	11	11	5	5	27	27	5	54	0					
Molanna	stone	0	0	0	0	0	0	0	0	0	0	0	0					
Total Stone Cases		11	27	11	16	16	27	492	81	65	108	76	76	18	150	84	93	66
Total Plant Cases		38	205	59	97	108	16	5	27	27	5	59	0	87	21	54	47	33
	Littoral Mean	stdev	se															
STONE CASES	36	47	17															
PLANT CASES	52	37	13															

Appendix Table IX. Tanypodinae and Other Chironomidae (numbers/m2) collected with the air-lift sampler in Flathead Lake and Lake McDonald, 1991. FN=Flathead Lake North Site; FS=Flathead Lake South Site; MN=Lake McDonald North Site; MS=Lake McDonald South Site; VZ=varial zone; PWZ=permanently wetted zone.

VZ-AUG	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-mean	S-Mean	Grand mean	stdev	se
Tanypodinae	70	108	54	49	38	59	76	97	59	43	59	32	63	61	62	1	1
Other Chironomidae	2405	3654	2173	2600	1973	1281	2605	1719	1378	730	935	595	2348	1327	1837	722	510
Total	2476	3762	2227	2649	2011	1341	2681	1816	1438	773	995	627	2411	1388	1900	723	511
VZ-OCT	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	N-mean	S-Mean	Grand mean	stdev	se
Tanypodinae	43	22	16	no count	no count	162	no count	no count	no count	no count	no count	no count	81	no count	61		
Other Chironomidae	173	822	303	no count	no count	211	no count	no count	no count	no count	no count	no count	377	no count	377		
Total	216	843	319	no count	368	373	205	924	195	205	no count	530	424	412	418	8	6
PWZ-MAY	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-mean	S-Mean	Grand mean	stdev	se
Tanypodinae	330	292	270	297	243	195	195	270	108	227	146	265	271	202	236	49	35
Other Chironomidae	11524	10081	8903	9984	8757	6259	7151	11925	6027	6595	5870	11535	9251	8184	8718	755	534
Total	11854	10373	9173	10281	9000	6454	7346	12195	6135	6822	6016	11800	9523	8386	8954	804	568
PWZ-AUG	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-mean	S-Mean	Grand mean	stdev	se
Tanypodinae	195	no count	254	232	no count	no count	486	330	373	330	238	303	227	343	285	82	58
Other Chironomidae	22324	no count	16281	24903	no count	no count	17665	13562	21070	9611	16686	10780	21169	14897	18033	4435	3136
Total	22519	23054	16535	25135	15600	20638	18151	13892	21443	9941	16924	11092	20580	15241	17910	3776	2670
PWZ-OCT	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	N-mean	S-Mean	Grand mean	stdev	se
Tanypodinae	288	141	114	130	292	135	335	205	238	200	270	335	183	264	223	57	41
Other Chironomidae	9822	9670	11005	10476	12741	8157	7389	8735	7584	6816	5611	9389	10312	7587	8950	1926	1362
Total	10108	9811	11119	10605	13032	8292	7724	8941	7822	7016	5881	9724	10495	7851	9173	1869	1322

VZ-AUG	MN-A-1	MN-A-2	MN-A-3	MN-A-4	MN-A-5	MN-A-6	MS-A-1	MS-A-2	MS-A-3	MS-A-4	MS-A-5	MS-A-6	N-Mean	S-Mean	Grand Mean	stdev	se
Tanypodinae	22	49	11	11	11	16	5	11	27	5	5	5	20	10	15	7	5
Other Chironomidae	2124	2265	1059	1957	2362	1449	1670	1757	2000	1476	1605	1000	1869	1651	1760	154	109
Total	2146	2314	1070	1968	2373	1465	1676	1768	2027	1481	1611	1005	1889	1661	1775	161	114
PWZ-MAY	MN-B-1	MN-B-2	MN-B-3	MN-B-4	MN-B-5	MN-B-6	MS-B-1	MS-B-2	MS-B-3	MS-B-4	MS-B-5	MS-B-6	N-Mean	S-Mean	Grand Mean	stdev	se
Tanypodinae	351	584	265	254		346	373	449	519	254	497	216	360	385	372	17	12
Other Chironomidae	8211	5249	2270	2622		3081	6962	8730	8119	4357	8670	4476	4326	6552	5439	1574	1113
Total	8562	5832	2535	3076		3427	7335	7178	8638	4611	9168	4692	4686	6937	5812	1591	1125
PWZ-AUG	MN-B-1	MN-B-2	MN-B-3	MN-B-4	MN-B-5	MN-B-6	MS-B-1	MS-B-2	MS-B-3	MS-B-4	MS-B-5	MS-B-6	N-Mean	S-Mean	Grand Mean	stdev	se
Tanypodinae	103	97	216	135	168	97	66	65	124	78	124	92	136	95	115	29	21
Other Chironomidae	4232	5876	4497	4243	5465	5908	6849	5930	3330	7897	5535	5627	5037	5895	5466	606	429
Total	4335	5973	4714	4378	5632	6005	6935	5995	3454	7973	5659	5919	5173	5989	5581	577	408
PWZ-OCT	MN-B-1	MN-B-2	MN-B-3	MN-B-4	MN-B-5	MN-B-6	MS-B-1	MS-B-2	MS-B-3	MS-B-4	MS-B-5	MS-B-6	N-Mean	S-Mean	Grand Mean	stdev	se
Tanypodinae	351	297	162	141	108	195	184	148	162	130	103	232	209	159	184	35	25
Other Chironomidae	2119	1957	3476	1427	3589	2762	10551	7735	3411	5946	11106	6335	2555	7846	5201	3743	2646
Total	2470	2254	3638	1568	3697	2957	10735	7861	3573	6076	11211	6568	2764	8007	5386	3708	2622

Appendix Table X.1. Macroinvertebrates (numbers/m2) collected in August 1991 with basket samplers (Flathead Lake 1.5m Wave Zone, North Site).

Order	Family	Genus	1	2	3	Mean	Std.
Amphipoda	Gammaridae	Gammarus lacustris	183	247	430	287	128
Amphipoda	Talitridae	Hyalella azteca	22	86	11	39	41
Ephemeroptera	Baetidae	Centroptilum	0	22	0	7	12
Ephemeroptera	Caenidae	Caenis	0	0	0	0	0
Ephemeroptera	Ephemeridae	Ephemera	0	0	0	0	0
Ephemeroptera	Heptageniidae	Heptagenia	0	32	0	11	19
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	387	301	1043	577	406
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	323	247	656	409	217
Ephemeroptera	Siphlonuridae	Ameletus	215	430	290	312	109
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	0	0	0	0
Trichoptera	Lepidostomatidae	Lepidostoma	86	333	75	165	146
Trichoptera	Leptoceridae	Ceraclea	161	172	269	201	59
Trichoptera	Leptoceridae	Mystacides	11	11	0	7	6
Trichoptera	Leptoceridae	Oecetis	301	290	269	287	16
Trichoptera		unknown immature	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	0	0	0	0
Trichoptera	Limnephilidae	Cliistoronia	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	0	0	0	0	0
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0
Pharyngodbellida	Erpobdellidae	Nephelopsis obscura	54	86	75	72	16
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	0	0	0
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	11	0	0	4	6
Gastropoda	Lymnaeidae	Stagnicola	97	237	333	222	119
Gastropoda	Physidae	Physella	11	22	0	11	11
Gastropoda	Planorbidae	Gyraulus	0	11	0	4	6
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0
Gastropoda	Planorbidae	Promentus	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	0	0	0	0
Plecoptera	Capniidae	Capnia	0	11	108	39	59
Plecoptera	Chloroperlidae	Suwallia	0	0	0	0	0
Coleoptera	Dytiscidae	larvae	0	0	0	0	0
Coleoptera	Dytiscidae	adult	0	0	0	0	0
Coleoptera	Elmidae	larvae	0	0	0	0	0
Coleoptera	Elmidae	adult	0	0	0	0	0
Hemiptera	Corixidae	unknown	0	0	0	0	0
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0
Diptera	Ceratopogonidae	Unknown	0	0	11	4	6
Diptera	Chironomidae		5677	4280	5699	5219	813

Appendix Table X.2. Macroinvertebrates (numbers/m2) collected in August 1991 with basket samplers (Flathead Lake 1.5m Wave Zone, South Site).

Order	Family	Genus	1	2	3	Mean	Std.	se
Amphipoda	Gammaridae	Gammarus lacustris	161	65	108	111	48	28
Amphipoda	Talitridae	Hyalella azteca	0	0	0	0	0	0
Ephemeroptera	Baetidae	Centroptilum	43	0	0	14	25	14
Ephemeroptera	Caenidae	Caenis	0	0	11	4	6	4
Ephemeroptera	Ephemeridae	Ephemera	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Heptagenia	871	355	505	577	265	153
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	0	0	11	4	6	4
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	226	355	312	297	66	38
Ephemeroptera	Siphlonuridae	Ameletus	0	65	75	47	41	24
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	0	11	4	6	4
Trichoptera	Lepidostomatidae	Lepidostoma	0	0	0	0	0	0
Trichoptera	Leptoceridae	Ceraclea	0	11	0	4	6	4
Trichoptera	Leptoceridae	Mystacides	0	0	0	0	0	0
Trichoptera	Leptoceridae	Oecetis	54	0	43	32	28	16
Trichoptera		unknownm immature	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	0	0	0	0	0
Trichoptera	Limnephilidae	Clistoronia	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	43	0	22	22	22	12
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0	0
Pharyngodbellida	Erpobdellidae	Nephelopsis obscura	0	43	11	18	22	13
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	0	0	0	0
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	0	0	0	0	0
Gastropoda	Lymnaeidae	Stagnicola	0	32	22	18	16	9
Gastropoda	Physidae	Physella	0	0	0	0	0	0
Gastropoda	Planorbidae	Gyraulus	75	11	22	36	35	20
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0	0
Gastropoda	Planorbidae	Promentus	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	0	0	0	0	0
Plecoptera	Capniidae	Capnia	0	0	0	0	0	0
Plecoptera	Chloroperlidae	Suwallia	0	0	0	0	0	0
Coleoptera	Dytiscidae	larvae	11	0	11	7	6	4
Coleoptera	Dytiscidae	adult	0	11	0	4	6	4
Coleoptera	Elmidae	larvae	0	0	0	0	0	0
Coleoptera	Elmidae	adults	0	0	0	0	0	0
Hemiptera	Corixidae	unknown	0	0	0	0	0	0
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0
Diptera	Ceratopogonidae	Unknown	0	0	0	0	0	0
Diptera	Chironomidae		8151	6667	8452	7756	956	552

Appendix Table X.3. Macroinvertebrates (numbers/m2) collected in August 1991 with basket samplers (Flathead Lake 4.5m Flat Bottom Zone, North Site).

Order	Family	Genus	1	2	3	Mean	Std.	se
Amphipoda	Gammaridae	Gammarus lacustris	806	355	430	530	242	140
Amphipoda	Talitridae	Hyalella azteca	828	903	785	839	60	35
Ephemeroptera	Baetidae	Centroptilum	22	97	0	39	51	29
Ephemeroptera	Caenidae	Caenis	0	0	0	0	0	0
Ephemeroptera	Ephemeridae	Ephemera	11	0	0	4	6	4
Ephemeroptera	Heptageniidae	Heptagenia	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	11	32	22	22	11	6
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	0	0	11	4	6	4
Ephemeroptera	Siphlonuridae	Ameletus	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	97	0	32	56	32
Trichoptera	Lepidostomatidae	Lepidostoma	0	22	0	7	12	7
Trichoptera	Leptoceridae	Ceraclea	215	151	194	186	33	19
Trichoptera	Leptoceridae	Mystacides	204	75	129	136	65	37
Trichoptera	Leptoceridae	Oecetis	118	183	269	190	76	44
Trichoptera		unknown immature	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	0	0	0	0	0
Trichoptera	Limnephilidae	Clistoronia	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	75	11	118	68	54	31
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0	0
Pharyngodbellida	Erpobdellidae	Nephelopsis obscura	183	118	129	143	35	20
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	32	22	0	18	16	9
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	22	11	11	11	6
Gastropoda	Lymnaeidae	Stagnicola	0	0	0	0	0	0
Gastropoda	Physidae	Physella	0	0	0	0	0	0
Gastropoda	Planorbidae	Gyraulus	43	11	32	29	16	9
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0	0
Gastropoda	Planorbidae	Promentus	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	43	43	43	43	0	0
Plecoptera	Capniidae	Capnia	0	0	0	0	0	0
Plecoptera	Chloroperlidae	Suwallia	0	0	11	4	6	4
Coleoptera	Dytiscidae	larvae	0	0	0	0	0	0
Coleoptera	Dytiscidae	adult	0	0	0	0	0	0
Coleoptera	Elmidae	larvae	0	0	0	0	0	0
Coleoptera	Elmidae	adult	0	0	0	0	0	0
Hemiptera	Corixidae	unknown	0	0	0	0	0	0
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0
Diptera	Ceratopogonidae	Unknown	0	0	0	0	0	0
Diptera	Chironomidae		18258	15742	21301	18434	2784	1607

Appendix Table X.4. Macroinvertebrates (numbers/m2) collected in August 1991 with basket samplers (Flathead Lake 4.5m Flat Bottom Zone, South Site).

Order	Family	Genus	1	2	3	Mean	Std.	se
Amphipoda	Gammaridae	Gammarus lacustris	118	140	118	125	12	7
Amphipoda	Talitridae	Hyalella azteca	871	860	688	806	103	59
Ephemeroptera	Baetidae	Centroptilum	0	0	0	0	0	0
Ephemeroptera	Caenidae	Caenis	0	22	0	7	12	7
Ephemeroptera	Ephemeridae	Ephemera	0	0	0	0	0	0
Ephemeroptera	Heptagenlidae	Heptagenia	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	11	0	22	11	11	6
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	97	172	86	118	47	27
Ephemeroptera	Siphlonuridae	Ameletus	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	22	0	7	12	7
Trichoptera	Lepidostomatidae	Lepidostoma	0	0	0	0	0	0
Trichoptera	Leptoceridae	Ceraclea	118	118	108	115	6	4
Trichoptera	Leptoceridae	Mystacides	11	22	22	18	6	4
Trichoptera	Leptoceridae	Oecetis	43	54	0	32	28	16
Trichoptera		unknown immature	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	0	0	0	0	0
Trichoptera	Limnephilidae	Clistoronia	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0
	Limnephilidae	Limnephilus	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	226	269	258	251	22	13
Trichoptera	Polycentropodidae	Nyctiophylax	11	11	0	7	6	4
Pharyngodbellida	Erpobdellidae	Nephelopsis obscura	32	22	0	18	16	9
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	11	4	6	4
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	0	0	0	0	0	0
Gastropoda	Lymnaeidae	Stagnicola	0	0	0	0	0	0
Gastropoda	Physidae	Physella	0	0	0	0	0	0
Gastropoda	Planorbidae	Gyraulus	204	226	86	172	75	43
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0	0
Gastropoda	Planorbidae	Promentus	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	0	22	7	12	7
Plecoptera	Capniidae	Capnia	0	0	0	0	0	0
Plecoptera	Chloroperlidae	Suwallia	0	0	0	0	0	0
Coleoptera	Dytiscidae	larvae	0	0	0	0	0	0
Coleoptera	Dytiscidae	adult	0	0	0	0	0	0
Coleoptera	Elmidae	larvae	0	0	0	0	0	0
Coleoptera	Elmidae	adult	0	0	0	0	0	0
Hemiptera	Corixidae	unknown	0	0	0	0	0	0
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0
Diptera	Ceratopogonidae	Unknown	0	0	0	0	0	0
Diptera	Chironomidae		21720	23398	17978	21032	2774	1602

Appendix Table X.5. Macroinvertebrates (numbers/m2) collected in August 1991 with basket samplers (Lake McDonald 3.5m Sloped Bottom Zone, North Site).

Order	Family	Genus	1	2	Mean	Std.	se
Amphipoda	Gammaridae	Gammarus lacustris	0	11	5	8	5
Amphipoda	Talitridae	Hyalella azteca	0	0	0	0	0
Ephemeroptera	Baetidae	Centroptilum	22	75	48	38	27
Ephemeroptera	Caenidae	Caenis	32	11	22	15	11
Ephemeroptera	Ephemeridae	Ephemera	0	0	0	0	0
Ephemeroptera	Heptageniidae	Heptagenia	0	0	0	0	0
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	1151	1011	1081	99	70
Ephemeroptera	Siphlonuridae	Ameletus	172	86	129	61	43
Ephemeroptera	Siphlonuridae	Siphlonurus	0	11	5	8	5
Trichoptera	Hydroptilidae	Hydroptila	0	0	0	0	0
Trichoptera	Lepidostomatidae	Lepidostoma	0	32	16	23	16
Trichoptera	Leptoceridae	Ceraclea	0	0	0	0	0
Trichoptera	Leptoceridae	Mystacides	86	0	43	61	43
Trichoptera	Leptoceridae	Oecetis	172	344	258	122	86
Trichoptera		unknown immature	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	22	0	11	15	11
Trichoptera	Limnephilidae	Clistoronia	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	22	22	22	0	0
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0
Pharyngodbellida	Erpobdellidae	Nephelopsis obscura	32	22	27	8	5
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	11	11	11	0	0
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	86	0	43	61	43
Gastropoda	Lymnaeidae	Stagnicola	0	0	0	0	0
Gastropoda	Physidae	Physella	32	0	16	23	16
Gastropoda	Planorbidae	Gyraulus	86	22	54	46	32
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0
Gastropoda	Planorbidae	Promentus	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	43	11	27	23	16
Plecoptera	Capniidae	Capnia	0	0	0	0	0
Plecoptera	Chloroperlidae	Suwallia	118	108	113	8	5
Coleoptera	Dytiscidae	larvae	0	0	0	0	0
Coleoptera	Dytiscidae	adult	0	0	0	0	0
Coleoptera	Elmidae	larvae	183	108	145	53	38
Coleoptera	Elmidae	adults	108	54	81	38	27
Hemiptera	Corixidae	unknown	172	43	108	91	65
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0
Diptera	Ceratopogonidae	Unknown	0	0	0	0	0
Diptera	Chironomidae		14065	13430	13747	449	317

Appendix Table X.6. Macroinvertebrates (numbers/m2) collected in August 1991 with basket samplers (Lake McDonald 3.5m Sloped Bottom Zone, South Site).

Order	Family	Genus	1	2	3	Mean	Std.	se
Amphipoda	Gammaridae	Gammarus lacustris	65	32	0	32	32	19
Amphipoda	Talitridae	Hyalella azteca	108	32	65	68	38	22
Ephemeroptera	Baetidae	Centroptilum	484	355	344	394	78	45
Ephemeroptera	Caenidae	Caenis	11	43	86	47	38	22
Ephemeroptera	Ephemeridae	Ephemera	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Heptagenia	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Leucrocuta	0	0	0	0	0	0
Ephemeroptera	Heptageniidae	Stenonema	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Leptophlebia	0	0	0	0	0	0
Ephemeroptera	Leptophlebiidae	Paraleptophlebia	1151	1419	1290	1287	134	78
Ephemeroptera	Siphlonuridae	Ameletus	0	0	0	0	0	0
Ephemeroptera	Siphlonuridae	Siphlonurus	0	0	0	0	0	0
Trichoptera	Hydroptilidae	Hydroptila	0	0	0	0	0	0
Trichoptera	Lepidostomatidae	Lepidostoma	108	97	97	100	6	4
Trichoptera	Leptoceridae	Ceraclea	0	0	0	0	0	0
Trichoptera	Leptoceridae	Mystacides	22	22	32	25	6	4
Trichoptera	Leptoceridae	Oecetis	0	0	0	0	0	0
Trichoptera		unknown immature	0	0	0	0	0	0
Trichoptera	Limnephilidae	Amphicosmoecus	0	0	0	0	0	0
Trichoptera	Limnephilidae	Anabolia	0	0	0	0	0	0
Trichoptera	Limnephilidae	Apatania	0	0	0	0	0	0
Trichoptera	Limnephilidae	Clistoronia	0	0	0	0	0	0
Trichoptera	Limnephilidae	Psychoglypha	0	0	0	0	0	0
Trichoptera	Limnephilidae	Limnephilus	0	0	0	0	0	0
Trichoptera	Molannidae	Molanna	0	0	0	0	0	0
Trichoptera	Polycentropodidae	Polycentropus	43	43	22	36	12	7
Trichoptera	Polycentropodidae	Nyctiophylax	0	0	0	0	0	0
Pharyngodbellida	Erpobdellidae	Nephelopsis obscura	32	140	22	65	65	38
Rhynchobdellida	Glossiphoniidae	Helobdella stagnalis	0	0	43	14	25	14
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	43	11	0	18	22	13
Gastropoda	Lymnaeidae	Stagnicola	0	0	0	0	0	0
Gastropoda	Physidae	Physella	11	54	11	25	25	14
Gastropoda	Planorbidae	Gyraulus	0	32	22	18	16	9
Gastropoda	Planorbidae	Helisoma anceps anceps	0	0	0	0	0	0
Gastropoda	Planorbidae	Promentus	0	0	0	0	0	0
Gastropoda	Valvatidae	Valvata humeralis	0	43	22	22	22	12
Plecoptera	Capniidae	Capnia	0	0	0	0	0	0
Plecoptera	Chloroperlidae	Suwallia	0	0	0	0	0	0
Coleoptera	Dytiscidae	larvae	0	0	0	0	0	0
Coleoptera	Dytiscidae	adult	0	0	0	0	0	0
Coleoptera	Elmidae	Total Elmidae	763	409	226	466	273	158
Coleoptera	Elmidae	Elmidae larvae	452	172	86	237	191	110
Coleoptera	Elmidae	Elmidae adults	312	237	140	229	86	50
Hemiptera	Corixidae	Hemiptera	11	11	0	7	6	4
Odonata	Gomphidae	Ophiogomphus	0	0	0	0	0	0
Diptera	Ceratopogonidae	unknown	0	0	0	0	0	0
Diptera	Chironomidae		12871	12441	14686	13333	1193	689

Appendix Table XI.1. Taxonomic orders (numbers/m2) collected in August 1991 with the air-lift sampler (Flathead Lake). FN=Flathead Lake North Site; FS=Flathead Lake South Site; A=samples collected at 1.5m wave zone; B=samples collected at 4.5m flat bottom zone.

	FN-A-1	FN-A-2	FN-A-3	FN-A-4	FN-A-5	FN-A-6	Mean	stdev	se
Amphipoda	146	178	373	535	330	422	331	148	60
Ephemeroptera	1238	1314	659	962	741	432	891	344	140
Trichoptera	141	222	368	114	146	259	208	96	39
Hirudinea	38	43	49	0	11	5	24	21	9
Gastropoda	216	146	151	243	178	81	169	57	23
Plecoptera	22	141	97	103	78	0	73	53	22
Coeloptera larvae	0	22	0	5	0	0	5	9	4
Coleoptera adults	0	0	0	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0	0	0	0
Chironomidae	2476	3762	2227	2649	2011	1341	2411	803	328
TOTAL	4276	5827	3924	4611	3492	2541	4112	1105	451
	FS-A-1	FS-A-2	FS-A-3	FS-A-4	FS-A-5	FS-A-6	Mean	stdev	se
Amphipoda	97	135	141	270	92	76	135	71	29
Ephemeroptera	146	124	141	141	151	135	140	9	4
Trichoptera	0	43	11	32	16	11	19	16	7
Hirudinea	0	5	0	0	0	5	2	3	1
Gastropoda	0	54	0	0	5	16	13	21	9
Plecoptera	0	0	0	0	0	0	0	0	0
Coeloptera larvae	0	11	5	0	0	5	4	4	2
Coleoptera adults	0	0	0	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0	0	0	0
Chironomidae	2681	1816	1438	773	995	627	1388	771	315
TOTAL	2924	2189	1735	1216	1259	876	1700	755	308
	FN-B-1	FN-B-2	FN-B-3	FN-B-4	FN-B-5	FN-B-6	Mean	stdev	se
Amphipoda	1216	1200	865	957	1011	611	977	226	92
Ephemeroptera	16	11	5	22	16	0	12	8	3
Trichoptera	70	27	27	70	49	65	51	20	8
Hirudinea	0	16	16	81	0	38	25	31	13
Gastropoda	54	114	216	276	49	43	125	99	40
Plecoptera	0	0	0	0	0	0	0	0	0
Coeloptera larvae	0	0	0	0	0	0	0	0	0
Coleoptera adults	0	0	0	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0	0	0	0
Chironomidae	22519	23054	16535	25135	15600	20638	20580	3789	1547
TOTAL	23876	24422	17665	26541	16724	21395	21770	3916	1599
	FS-B-1	FS-B-2	FS-B-3	FS-B-4	FS-B-5	FS-B-6	Mean	stdev	se
Amphipoda	724	641	714	692	673	768	668	91	37
Ephemeroptera	65	49	70	65	38	22	51	19	8
Trichoptera	54	86	27	32	11	27	40	27	11
Hirudinea	0	0	0	0	5	0	1	2	1
Gastropoda	54	146	5	49	27	49	55	48	20
Plecoptera	0	0	0	0	0	0	0	0	0
Coeloptera larvae	0	0	0	0	0	0	0	0	0
Coleoptera adults	0	0	0	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0	0	0	0
Chironomidae	18151	13892	21443	9941	16924	11092	15241	4402	1797
TOTAL	19049	14714	22259	10778	17578	11957	16056	4387	1791

Appendix Table XI.2. Taxonomic orders (numbers/m2) collected in August 1991 with the air-lift sampler (Lake McDonald). MN=Lake McDonald North Site; MS=Lake McDonald South Site; B=samples collected at 3.5m sloped bottom zone.

	MN-B-1	MN-B-2	MN-B-3	MN-B-4	MN-B-5	MN-B-6	Mean	stdev	se
Amphipoda	103	32	103	59	119	124	90	36	15
Ephemeroptera	286	281	76	119	595	151	251	189	77
Trichoptera	168	151	157	124	178	151	155	18	7
Hirudinea	0	5	5	16	0	0	5	6	3
Gastropoda	114	16	38	124	16	65	62	48	19
Plecoptera	11	11	0	5	49	11	14	17	7
Coeloptera larvae	27	114	97	43	119	43	74	41	17
Coleoptera adults	5	27	0	5	43	5	14	17	7
Hemiptera	22	0	0	0	0	0	4	9	4
Chironomidae	4335	5973	4714	4378	5632	6005	5173	786	321
TOTAL	5070	6611	5189	4876	6751	6557	5842	881	360
	MS-B-1	MS-B-2	MS-B-3	MS-B-4	MS-B-5	MS-B-6	Mean	stdev	se
Amphipoda	32	59	5	632	76	59	144	240	98
Ephemeroptera	135	119	27	135	151	178	124	52	21
Trichoptera	70	81	59	108	135	65	86	29	12
Hirudinea	0	0	0	0	11	0	2	4	2
Gastropoda	32	43	22	108	0	16	37	38	15
Plecoptera	0	0	0	0	0	0	0	0	0
Coeloptera larvae	146	108	0	27	119	124	87	59	24
Coleoptera adults	11	16	0	54	65	76	37	32	13
Hemiptera	43	5	0	16	16	5	14	16	6
Chironomidae	6935	5995	3454	7973	5659	5919	5989	1508	616
TOTAL	7405	6427	3568	9054	6232	6443	6522	1790	731

Appendix Table XII.1. Taxonomic orders (numbers/m2) collected in August 1991 with basket samplers (Flathead Lake). FN=Flathead Lake North Site; FS=Flathead Lake South Site; A=samples collected at 1.5m wave zone; B=samples collected at 4.5m flat bottom zone.

	FN-A-1	FN-A-2	FN-A-3	Mean	stdev	se
Amphipoda	204	333	441	326	118	68
Ephemeroptera	925	1032	1989	1315	586	338
Trichoptera	559	806	613	659	130	75
Hirudinea	65	86	75	75	11	6
Gastropoda	108	269	333	237	116	67
Plecoptera	0	11	108	39	59	34
Coeloptera larvae	0	0	0	0	0	0
Coleoptera adults	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0
Chironomidae	5677	4280	5699	5219	813	470
TOTAL	7538	6817	9258	7871	1254	724
	FS-A-1	FS-A-2	FS-A-3	Mean	stdev	se
Amphipoda	161	65	108	111	48	28
Ephemeroptera	1140	774	914	943	184	107
Trichoptera	97	11	75	61	45	26
Hirudinea	0	43	11	18	22	13
Gastropoda	75	43	43	54	19	11
Plecoptera	0	0	0	0	0	0
Coeloptera larvae	11	0	11	7	6	4
Coleoptera adults	0	11	0	4	6	4
Hemiptera	0	0	0	0	0	0
Chironomidae	8151	6667	8452	7756	956	552
TOTAL	9634	7613	9613	8953	1161	670
	FN-B-1	FN-B-2	FN-B-3	Mean	stdev	se
Amphipoda	1634	1258	1215	1369	231	133
Ephemeroptera	43	129	32	68	53	31
Trichoptera	613	538	710	620	86	50
Hirudinea	215	161	140	172	39	22
Gastropoda	86	54	75	72	16	9
Plecoptera	0	0	11	4	6	4
Coeloptera larvae	0	0	0	0	0	0
Coleoptera adults	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0
Chironomidae	18258	15742	21301	18434	2784	1607
TOTAL	20849	17882	23484	20738	2803	1618
	FS-B-1	FS-B-2	FS-B-3	Mean	stdev	se
Amphipoda	989	1000	806	932	109	63
Ephemeroptera	108	194	108	136	50	29
Trichoptera	409	495	387	430	57	33
Hirudinea	32	22	11	22	11	6
Gastropoda	204	226	108	179	63	36
Plecoptera	0	0	0	0	0	0
Coeloptera larvae	0	0	0	0	0	0
Coleoptera adults	0	0	0	0	0	0
Hemiptera	0	0	0	0	0	0
Chircnomidae	21720	23398	17978	21032	2774	1602
TOTAL	23462	25333	19398	22731	3035	1752

Appendix Table XII.2. Taxonomic orders (numbers/m2) collected in August 1991 with basket samplers (Lake McDonald). MN=Lake McDonald North Site; MS=Lake McDonald South Site; B=samples collected at 3.5m sloped bottom zone.

Order	MN-b-1	MN-b-2	MN-B-3	Mean	stdev	se
Amphipoda	0	11	no count	5	8	5
Ephemeroptera	1376	1194	no count	1285	129	91
Trichoptera	301	398	no count	349	68	48
Hirudinea	129	32	no count	81	68	48
Gastropoda	161	32	no count	97	91	65
Plecoptera	118	108	no count	113	8	5
Coeloptera larvae	183	108	no count	102	53	37
Coleoptera adults	108	54	no count	81	38	27
Hemiptera	172	43	no count	108	91	65
Chironomidae	14065	13430	no count	13747	449	317
TOTAL	16613	15410	no count	16011	851	602
	MS-B-1	MS-B-2	MS-B-3	Mean	stdev	se
Amphipoda	172	65	65	100	62	36
Ephemeroptera	1645	1817	1720	1728	86	50
Trichoptera	172	161	151	161	11	6
Hirudinea	75	151	65	97	47	27
Gastropoda	11	129	54	65	60	35
Plecoptera	0	0	0	0	0	0
Coleoptera larvae	452	172	86	237	191	110
Coleoptera adults	312	237	140	229	86	50
Hemiptera	11	11	0	7	6	4
Chironomidae	12871	12441	14688	13333	1193	689
TOTAL	15721	15183	16968	15957	916	529

Appendix Table XIII. Air-lift efficiency calculations for Flathead Lake 1.5m Wave Zone.

Efficiency Trial:	A	A	A	B	B	B	C	C	C	Total #	Total #	Total #	Grand Total
Removal Number:	1	2	3	1	2	3	1	2	3	1	2	3	
Raw Numbers/sample													
Chironomidae	68	38	16	69	8	22	36	5	3	173	51	41	265
Ephemeroptera	118	44	21	208	47	20	38	11	4	364	102	45	511
Trichoptera	14	12	4	14	4	3	1	0	1	29	16	8	53
Plecoptera	0	2	1	8	2	0	0	1	0	8	5	1	14
Gastropoda	26	2	1	13	0	0	1	0	0	40	2	1	43
Amphipoda	21	6	2	17	1	1	7	1	1	45	8	4	57
Hirudinea	0	0	1	1	0	0	1	0	0	2	0	1	3
Total Organisms	247	104	46	330	62	46	84	18	9	661	184	101	946
Efficiencies:	A1	A2	A3	B1	B2	B3	C1	C2	C3	Mean 1	Mean 2	Mean 3	
Chironomidae	56%	31%	13%	70%	8%	22%	82%	11%	7%	69%	17%	14%	
Ephemeroptera	64%	24%	11%	76%	17%	7%	72%	21%	8%	71%	21%	9%	
Trichoptera	47%	40%	13%	67%	19%	14%	50%	0%	50%	54%	20%	26%	
Plecoptera	0%	67%	33%	80%	20%	0%	0%	100%	0%	27%	62%	11%	
Gastropoda	90%	7%	3%	100%	0%	0%	100%	0%	0%	97%	2%	1%	
Amphipoda	72%	21%	7%	89%	5%	5%	78%	11%	11%	80%	12%	8%	
Hirudinea	0%	0%	100%	100%	0%	0%	100%	0%	0%	67%	0%	33%	
Total Organisms	62%	26%	12%	75%	14%	11%	76%	16%	8%	71%	19%	10%	

Appendix Table XIV.1. ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 1.5m Wave Zone).

Anova table for a 2-factor Analysis of Variance on Y_1: Chironomidae

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	2296235.111	2296235.111	3.441	.0846
Sampler (B)	1	84198976	84198976	126.176	.0001
AB	1	12678347.111	12678347.111	18.999	.0007
Error	14	9342398.667	667314.19		

1

There were no missing cells found.

The AB incidence table on Y_1: Chironomidae

	Sampler:	vac	basket	Totals:
Sites unp.	fn-a	6 2411	3 5218.667	9 3346.889
	fs-a	6 1388.333	3 7756.667	9 3511.111
Totals:		12 1899.667	6 6487.667	18 3429

2

Anova table for a 2-factor Analysis of Variance on Y_2: Ephemeroptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	1263376	1263376	13.136	.0028
Sampler (B)	1	1506347.111	1506347.111	15.662	.0014
AB	1	143368.444	143368.444	1.491	.2422
Error	14	1346498.667	96178.476		

3

There were no missing cells found.

The AB incidence table on Y_2: Ephemeroptera

	Sampler:	vac	basket	Totals:
Sites unp.	fn-a	6 891	3 1315.333	9 1032.444
	fs-a	6 139.667	3 942.667	9 407.333
Totals:		12 515.333	6 1129	18 719.889

4

Appendix Table XIV.1 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 1.5m Wave Zone).

Anova table for a 2-factor Analysis of Variance on Y_3: Trichoptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	620681.361	620681.361	102.805	.0001
Sampler (B)	1	243213.361	243213.361	40.284	.0001
AB	1	167144.694	167144.694	27.684	.0001
Error	14	84524.833	6037.488		

5

There were no missing cells found.

The AB Incidence table on Y_3: Trichoptera

	Sampler:	vac	basket	Totals:
Sites unp..	fn-a	6 208.333	3 659.333	9 358.667
	fs-a	6 18.833	3 61	9 32.889
Totals:		12 113.583	6 360.167	18 195.778

6

Anova table for a 2-factor Analysis of Variance on Y_4: Plecoptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	12731.361	12731.361	8.446	.0115
Sampler (B)	1	1122.25	1122.25	.744	.4028
AB	1	1122.25	1122.25	.744	.4028
Error	14	21103.5	1507.393		

7

There were no missing cells found.

The AB Incidence table on Y_4: Plecoptera

	Sampler:	vac	basket	Totals:
Sites unp..	fn-a	6 73.167	3 39.667	9 62
	fs-a	6 0	3 0	9 0
Totals:		12 36.583	6 19.833	18 31

8

Appendix Table XIV.1 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 1.5m Wave Zone).

Anova table for a 2-factor Analysis of Variance on Yg: Coleoptera larvae

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	40.111	40.111	.993	.336
Sampler (B)	1	.444	.444	.011	.918
AB	1	69.444	69.444	1.719	.211
Error	14	565.667	40.405		

9

There were no missing cells found.

The AB incidence table on Yg: Coleoptera larvae

	Sampler:	vac	basket	Totals:
Sites unp.	fn-a	6 4.5	3 0	9 3
	fs-a	6 3.5	3 7.333	9 4.778
Totals:		12 4	6 3.667	18 3.889

10

Anova table for a 2-factor Analysis of Variance on Yg: Coleoptera adults

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	13.444	13.444	2.333	.1489
Sampler (B)	1	13.444	13.444	2.333	.1489
AB	1	13.444	13.444	2.333	.1489
Error	14	80.667	5.762		

11

There were no missing cells found.

The AB incidence table on Yg: Coleoptera adults

	Sampler:	vac	basket	Totals:
Sites unp.	fn-a	6 0	3 0	9 0
	fs-a	6 0	3 3.667	9 1.222
Totals:		12 0	6 1.833	18 .611

12

Appendix Table XIV.1 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 1.5m Wave Zone).

Anova table for a 2-factor Analysis of Variance on Y7: Hemiptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	0	0	.	.
Sampler (B)	1	0	0	.	.
AB	1	0	0	.	.
Error	14	0	0		

13

There were no missing cells found.

The AB incidence table on Y7: Hemiptera

	Sampler:	vac	basket	Totals:
Sites unp.:	fn-a	6 0	3 0	9 0
	fs-a	6 0	3 0	9 0
Totals:		12 0	6 0	18 0

14

Anova table for a 2-factor Analysis of Variance on Y8: Amphipoda

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	168236.694	168236.694	14.094	.0021
Sampler (B)	1	812.25	812.25	.068	.798
AB	1	367.361	367.361	.031	.8633
Error	14	167112.833	11936.631		

15

There were no missing cells found.

The AB incidence table on Y8: Amphipoda

	Sampler:	vac	basket	Totals:
Sites unp.:	fn-a	6 330.667	3 328	9 329.111
	fs-a	6 135.167	3 111.333	9 127.222
Totals:		12 232.917	6 218.667	18 228.167

16

Appendix Table XIV.1 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 1.5m Wave Zone).

Anova table for a 2-factor Analysis of Variance on Y_8: Gastropods

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	115373.444	115373.444	34.972	.0001
Sampler (B)	1	11808.444	11808.444	3.579	.0794
AB	1	693.444	693.444	.21	.6536
Error	14	46185.667	3298.976		

17

There were no missing cells found.

The AB incidence table on Y_8: Gastropods

	Sampler:	vac	basket	Totals:
Sites unp.	fn-a	6 169.167	3 236.667	9 191.667
	fs-a	6 12.5	3 53.667	9 26.222
Totals:		12 90.833	6 145.167	18 108.944

18

Anova table for a 2-factor Analysis of Variance on Y_{10}: Hirudinea

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	6400	6400	25.316	.0002
Sampler (B)	1	4533.778	4533.778	17.934	.0008
AB	1	1201.778	1201.778	4.754	.0468
Error	14	3539.333	252.81		

19

There were no missing cells found.

The AB incidence table on Y_{10}: Hirudinea

	Sampler:	vac	basket	Totals.
Sites unp.	fn-a	6 24.333	3 75.333	9 41.333
	fs-a	6 1.667	3 18	9 7.111
Totals:		12 13	6 46.667	18 24.222

20

Appendix Table XIV.1 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 1.5m Wave Zone).

Anova table for a 2-factor Analysis of Variance on Y_{11}: Total Organisms

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	1768013.444	1768013.444	1.673	.2167
Sampler (B)	1	121278827.111	121278827.111	114.788	.0001
AB	1	12210365.444	12210365.444	11.557	.0043
Error	14	14791676.333	1056548.31		

21

There were no missing cells found.

The AB incidence table on Y_{11}: Total Organisms

	Sampler:	vac	basket	Totals:
Sites unp...	fn-a	6 4111.833	3 7871	9 5364.889
	fs-a	6 1699.833	3 8953.333	9 4117.667
Totals:		12 2905.833	6 8412.167	18 4741.278

22

Appendix Table XIV.2. ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 4.5m Flat Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y_1: Chironomidae

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	7514908.444	7514908.444	.527	.4798
Sampler (B)	1	13286025	13286025	.932	.3507
AB	1	63011844	63011844	4.42	.0541
Error	14	199579349	14255667.786		

1

There were no missing cells found.

The AB incidence table on Y_1: Chironomidae

	Sampler:	vac	basket	Totals
Sites unp..	fs-b	6 15240.5	3 21032	9 17171
	fn-b	6 20580.167	3 18433.667	9 19864.667
Totals:		12 17910.333	6 19732.833	18 18517.833

2

Anova table for a 2-factor Analysis of Variance on Y_2: Ephemeroptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	11772.25	11772.25	13.015	0029
Sampler (B)	1	20022.25	20022.25	22.135	0003
AB	1	831.361	831.361	.919	354
Error	14	12663.5	904.536		

3

There were no missing cells found.

The AB incidence table on Y_2: Ephemeroptera

	Sampler:	vac	basket	Totals
Sites unp..	fs-b	6 51.5	3 136.667	9 79.889
	fn-b	6 11.667	3 68	9 30.444
Totals:		12 31.583	6 102.333	18 55.167

4

Appendix Table XIV.2 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 4.5m Flat Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y_3: Trichoptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	40736.694	40736.694	21.112	.0004
Sampler (B)	1	921280.028	921280.028	477.45	.0001
AB	1	31743.361	31743.361	16.451	.0012
Error	14	27014.167	1929.583		

5

There were no missing cells found.

The AB incidence table on Y_3: Trichoptera

	Sampler:	vac	basket	Totals:
Sites unp.	fs-b	6 39.5	3 430.333	9 169.778
	fn-b	6 51.333	3 620.333	9 241
Totals:		12 45.417	6 525.333	18 205.389

6

Anova table for a 2-factor Analysis of Variance on Y_4: Plecoptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	13.444	13.444	2.333	.1489
Sampler (B)	1	13.444	13.444	2.333	.1489
AB	1	13.444	13.444	2.333	.1489
Error	14	80.667	5.762		

7

There were no missing cells found.

The AB incidence table on Y_4: Plecoptera

	Sampler:	vac	basket	Totals
Sites unp.	fs-b	6 0	3 0	9 0
	fn-b	6 0	3 3.667	9 1.222
Totals:		12 0	6 1.833	18 .611

8

Appendix Table XIV.2 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 4.5m Flat Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Yg: Coleoptera larvae

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	0	0	.	.
Sampler (B)	1	0	0	.	.
AB	1	0	0	.	.
Error	14	0	0		

9

There were no missing cells found.

The AB Incidence table on Yg: Coleoptera larvae

	Sampler:	vac	basket	Totals:
Sites unp.:	fs-b	6 0	3 0	9 0
	fn-b	6 0	3 0	9 0
Totals:		12 0	6 0	18 0

10

Anova table for a 2-factor Analysis of Variance on Yg: Coleoptera adult

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	0	0	.	.
Sampler (B)	1	0	0	.	.
AB	1	0	0	.	.
Error	14	0	0		

11

There were no missing cells found.

The AB Incidence table on Yg: Coleoptera adult

	Sampler:	vac	basket	Totals:
Sites unp.:	fs-b	6 0	3 0	9 0
	fn-b	6 0	3 0	9 0
Totals:		12 0	6 0	18 0

12

Appendix Table XIV.2 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 4.5m Flat Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y7: Hemiptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	0	0	.	.
Sampler (B)	1	0	0	.	.
AB	1	0	0	.	.
Error	14	0	0		

13

There were no missing cells found.

The AB incidence table on Y7: Hemiptera

	Sampler:	vac	basket	Totals:
Sites unp.	fs-b	6 0	3 0	9 0
	fn-b	6 0	3 0	9 0
Totals:		12 0	6 0	18 0

14

Anova table for a 2-factor Analysis of Variance on Y8: Amphipoda

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	555521.778	555521.778	18.261	.0008
Sampler (B)	1	429461.778	429461.778	14.117	.0021
AB	1	16727.111	16727.111	.55	.4706
Error	14	425895.333	30421.095		

15

There were no missing cells found.

The AB incidence table on Y8: Amphipoda

	Sampler:	vac	basket	Totals:
Sites unp.	fs-b	6 668.667	3 931.667	9 756.333
	fn-b	6 978.667	3 1369	9 1107.444
Totals:		12 822.667	6 1150.333	18 931.889

16

Appendix Table XIV.2 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 4.5m Flat Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y_8: Gastropda

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	1393.778	1393.778	.284	.6027
Sampler (B)	1	4993.778	4993.778	1.016	.3305
AB	1	31684	31684	6.449	.0236
Error	14	68784.667	4913.19		

17

There were no missing cells found.

The AB incidence table on Y_8: Gastropda

	Sampler:	vac	basket	Totals:
Sites unp..	fs-b	6 55	3 179.333	9 96.444
	fn-b	6 125.333	3 71.667	9 107.444
Totals:		12 90.167	6 125.5	18 101.944

18

Anova table for a 2-factor Analysis of Variance on Y_{10}: Hirudinea

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	30508.444	30508.444	53.71	.0001
Sampler (B)	1	28112.111	28112.111	49.491	.0001
AB	1	15876	15876	27.95	.0001
Error	14	7952.333	568.024		

19

There were no missing cells found.

The AB incidence table on Y_{10}: Hirudinea

	Sampler.	vac	basket	Totals:
Sites unp..	fs-b	6 .833	3 21.667	9 7.778
	fn-b	6 25.167	3 172	9 74.111
Totals:		12 13	6 98.833	18 40.944

20

Appendix Table XIV.2 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Flathead Lake 4.5m Flat Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y_{11}: Total Organisms

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites unpooled (A)	1	13855765.444	13855765.444	.937	.3495
Sampler (B)	1	31847211.111	31847211.111	2.154	.1643
AB	1	59397849	59397849	4.017	.0648
Error	14	207019785	14787127.5		

21

There were no missing cells found.

The AB incidence table on Y_{11}: Total Organisms

	Sampler:	vac	basket	Totals:
Sites unp.	fs-b	6 16055.833	3 22731	9 18280.889
	fn-b	6 21770.5	3 20738.667	9 21426.556
Totals:		12 18913.167	6 21734.833	18 19853.722

22

Appendix Table XIV.3. ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Lake McDonald Sloped Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y_1: Chironomidae

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	428644.024	428644.024	.315	.5843
Sampler (B)	1	215546466.881	215546466.881	158.334	.0001
AB	1	734185.929	734185.929	.539	.4758
Error	13	17697372.833	1361336.372		

1

There were no missing cells found.

The AB Incidence table on Y_1: Chironomidae

	Sampler:	vac	basket	Totals:
Sites	ms-b	6 5989.167	3 13455.333	9 8477.889
	mn-b	6 5172.833	2 13564.5	8 7270.75
Totals:		12 5581	5 13499	17 7909.824

2

Anova table for a 2-factor Analysis of Variance on Y_2: Ephemeroptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	206360.381	206360.381	8.957	.0104
Sampler (B)	1	6710403.429	6710403.429	291.273	.0001
AB	1	47874.381	47874.381	2.078	.1731
Error	13	299496.667	23038.205		

3

There were no missing cells found.

The AB Incidence table on Y_2: Ephemeroptera

	Sampler:	vac	basket	Totals:
Sites	ms-b	6 124.167	3 1405	9 551.111
	mn-b	6 251.333	2 1768.5	8 630.625
Totals.		12 187.75	5 1550.4	17 588.529

4

Appendix Table XIV.3 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Lake McDonald Sloped Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y_3: Trichoptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	3714.881	3714.881	1.519	.2396
Sampler (B)	1	36080.024	36080.024	14.755	.002
AB	1	35264.024	35264.024	14.421	.0022
Error	13	31788.833	2445.295		

5

There were no missing cells found.

The AB Incidence table on Y_3: Trichoptera

	Sampler:	vac	basket	Totals:
Sites	ms-b	6 86.333	3 290.333	9 154.333
	mn-b	6 154.833	2 156	8 155.125
Totals:		12 120.583	5 236.6	17 154.706

6

Anova table for a 2-factor Analysis of Variance on Y_4: Plecoptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	3172.024	3172.024	4.087	.0643
Sampler (B)	1	3172.024	3172.024	4.087	.0643
AB	1	6917.167	6917.167	8.912	.0105
Error	13	10090.167	776.167		

7

There were no missing cells found.

The AB Incidence table on Y_4: Plecoptera

	Sampler:	vac	basket	Totals:
Sites	ms-b	6 0	3 75.333	9 25.111
	mn-b	6 14.5	2 0	8 10.875
Totals:		12 7.25	5 45.2	17 18.412

8

Appendix Table XIV.3 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Lake McDonald Sloped Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y$_5$: Coleoptera larvae

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	14972.595	14972.595	2.051	.1757
Sampler (B)	1	39805.929	39805.929	5.452	.0362
AB	1	9480.024	9480.024	1.299	.275
Error	13	94906.833	7300.526		

9

There were no missing cells found.

The AB incidence table on Y$_5$: Coleoptera larvae

	Sampler:	vac	basket	Totals:
Sites	me-b	6 87.333	3 247.667	9 140.778
	mn-b	6 73.833	2 129	8 87.625
Totals:		12 80.583	5 200.2	17 115.765

10

Anova table for a 2-factor Analysis of Variance on Y$_6$: Coleoptera adults

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	50.381	50.381	.014	.909
Sampler (B)	1	74761.524	74761.524	20.137	.0006
AB	1	2438.095	2438.095	.657	.4323
Error	13	48265.333	3712.718		

11

There were no missing cells found.

The AB incidence table on Y$_6$: Coleoptera adults

	Sampler:	vac	basket	Totals:
Sites	me-b	6 37	3 158	9 77.333
	mn-b	6 14.167	2 188.5	8 57.75
Totals:		12 25.583	5 170.2	17 68.118

12

Appendix Table XIV.3. ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Lake McDonald Sloped Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y7: Hemiptera

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	5531.524	5531.524	4.439	.0551
Sampler (B)	1	3402	3402	2.73	.1224
AB	1	3017.524	3017.524	2.422	.1437
Error	13	16199.333	1246.103		

13

There were no missing cells found.

The AB incidence table on Y7: Hemiptera

	Sampler:	vac	basket	Totals:
Sites	ms-b	6 14.167	3 75.333	9 34.556
	mn-b	6 3.667	2 5.5	8 4.125
Totals:		12 8.917	5 47.4	17 20.235

14

Anova table for a 2-factor Analysis of Variance on Y8: Amphipoda

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	2128.595	2128.595	.088	.7714
Sampler (B)	1	9966.881	9966.881	.412	.532
AB	1	2866.881	2866.881	.119	.7361
Error	13	314264.833	24175.756		

15

There were no missing cells found.

The AB incidence table on Y8: Amphipoda

	Sampler:	vac	basket	Totals:
Sites	ms-b	6 143.833	3 61	9 116.222
	mn-b	6 90	2 65	8 83.75
Totals:		12 116.917	5 62.8	17 100.941

16

Appendix Table XIV.3 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Lake McDonald Sloped Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y_8: Gastropods

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	2044.024	2044.024	.77	.3961
Sampler (B)	1	3137.357	3137.357	1.182	.2967
AB	1	2.881	2.881	.001	.9742
Error	13	34508.167	2654.474		

17

There were no missing cells found.

The AB incidence table on Y_8: Gastropods

	Sampler:	vac	basket	Totals:
Sites	ms-b	6 36.833	3 68	9 47.222
	mn-b	6 82.167	2 91.5	8 69.5
Totals:		12 49.5	5 77.4	17 57.706

18

Anova table for a 2-factor Analysis of Variance on Y_{10}: Hirudinea

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	868.595	868.595	1.295	.2756
Sampler (B)	1	27925.929	27925.929	41.648	.0001
AB	1	617.167	617.167	.92	.3549
Error	13	8716.833	670.526		

19

There were no missing cells found.

The AB incidence table on Y_{10}: Hirudinea

	Sampler:	vac	basket	Totals:
Sites	ms-b	6 1.833	3 78.667	9 27.444
	mn-b	6 4.333	2 108	8 30.25
Totals:		12 3.083	5 90.4	17 28.765

20

Appendix Table XIV.3 (continued). ANOVA's between major taxonomic groups in August 1991 air-lift and basket samples (Lake McDonald Sloped Bottom Zone).

Anova table for a 2-factor Analysis of Variance on Y_{11}: Total Organisms

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sites (A)	1	334285.929	334285.929	.195	.6662
Sampler (B)	1	329442420.024	329442420.024	191.987	.0001
AB	1	461161.929	461161.929	.269	.6129
Error	13	22307487.167	1715960.551		

21

There were no missing cells found.

The AB incidence table on Y_{11}: Total Organisms

	Sampler:	vac	basket	Totals:
Sites	ms-b	6 6521.333	3 15957	9 9666.556
	mn-b	6 5842.333	2 16011.5	8 8384.625
Totals:		12 6181.833	5 15978.8	17 9063.294

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